

**EXPERIMENTAL DATA FROM FAULT  
DETECTION AND DIAGNOSTIC STUDIES  
ON A CENTRIFUGAL CHILLER**

Sponsored by

ASHRAE

Deliverable for Research Project 1043-RP

Fault Detection and Diagnostic (FDD)

Requirements and Evaluation Tools for Chillers

HL 99-18    Report #4036-1

Submitted by:        Mathew C. Comstock, Graduate Research Assistant  
                             James E. Braun, Principal Investigator

Approved by:        Robert J. Bernhard, Director  
                             Ray W. Herrick Laboratories

DECEMBER 1999

## Table of Contents

1.0	Introduction.....	5
2.0	Test Data from Fault Studies .....	5
	Normal Tests.....	13
	Normal Tests.....	13
2.1	Reduced Condenser Water Flow.....	31
2.2	Reduced Evaporator Water Flow.....	37
2.3	Refrigerant Leak .....	44
2.4	Refrigerant Overcharge.....	50
2.5	Excess Oil .....	55
2.6	Condenser Fouling .....	61
2.7	Non-Condensables in Refrigerant .....	67
2.8	Defective Pilot Valve .....	75
2.9	Multiple Faults .....	77
3.0	Conclusion and Recommendations .....	79

## List of Tables

Table 2.1: Definition of terms used in steady state data presentation .....	6
Table 2.2: Exported data from experimental test runs .....	8
Table 2.3: Sequence of testing and file names.....	11
Table 2.4: Recommended benchmark tests for each fault tested.....	13
Table 2.5: Near Normal 1 test run steady state data .....	14
Table 2.6: Near Normal 2 test run steady state data .....	15
Table 2.7: Near Normal 3 test run steady state data .....	16
Table 2.8: Normal test run steady state data .....	17
Table 2.9: Normal 1 test run steady state data .....	18
Table 2.10: Normal 2 test run steady state data .....	19
Table 2.11: Normal R test run steady state data .....	20
Table 2.12: Normal R1 test run steady state data .....	21
Table 2.13: Normal EO test run steady state data.....	22
Table 2.14: Normal CF test run steady state data .....	23
Table 2.15: Normal CF2 test run steady state data .....	24
Table 2.16: Normal CF3 test run steady state data .....	25
Table 2.17: Normal CF4 test run steady state data .....	26
Table 2.18: Normal CF5 test run steady state data .....	27
Table 2.19: Normal CF6 test run steady state data .....	28
Table 2.20: Normal NC test run steady state data .....	29
Table 2.21: Normal DPV test run steady state data .....	30
Table 2.22: Fault levels for reduced condenser water flow .....	31
Table 2.23: FWC10 test run steady state data.....	32
Table 2.24: FWC20 alt test run steady state data.....	33
Table 2.25: FWC20 test run steady state data.....	34
Table 2.26: FWC30 test run steady state data.....	35
Table 2.27: FWC40 test run steady state data.....	36
Table 2.28: Fault levels for reduced evaporator water flow.....	37
Table 2.29: FWE10 test run steady state data .....	38
Table 2.30: FWE20 alt test run steady state data .....	39
Table 2.31: FWE20 test run steady state data .....	40
Table 2.32: FWE30 test run steady state data .....	41
Table 2.33: FWE40 alt test run steady state data .....	42
Table 2.34: FWE40 test run steady state data .....	43
Table 2.35: Fault levels for refrigerant leak.....	44
Table 2.36: RL10 test run steady state data .....	45
Table 2.37: RL20 test run steady state data .....	46
Table 2.38: RL30 test run steady state data .....	47
Table 2.39: RL40 alt test run steady state data .....	48
Table 2.40: RL40 test run steady state data .....	49
Table 2.41: Fault levels for refrigerant overcharge .....	50
Table 2.42: RO10 test run steady state data.....	51
Table 2.43: RO20 test run steady state data.....	52
Table 2.44: RO30 test run steady state data.....	53

Table 2.45: RO40 test run steady state data.....	54
Table 2.46: Fault levels for excess oil .....	55
Table 2.47: EO14 test run steady state data.....	56
Table 2.48: EO32 test run steady state data.....	57
Table 2.49: EO50 test run steady state data.....	58
Table 2.50: EO68 test run steady state data.....	59
Table 2.51: EO73 test run steady state data.....	60
Table 2.52: Fault levels for condenser fouling .....	61
Table 2.53: CF6 test run steady state data .....	62
Table 2.54: CF12 test run steady state data .....	63
Table 2.55: CF20 test run steady state data .....	64
Table 2.56: CF30 test run steady state data .....	65
Table 2.57: CF45 test run steady state data .....	66
Table 2.58: Fault levels for non-condensables in refrigerant .....	67
Table 2.59: NC1 test run steady state data.....	68
Table 2.60: NC2 test run steady state data.....	69
Table 2.61: NC3 test run steady state data.....	70
Table 2.62: NC5 test run steady state data.....	71
Table 2.63: NC Trace test run steady state data.....	72
Table 2.64: NC Trace 2 test run steady state data.....	73
Table 2.65: Modified NC test run steady state data.....	74
Table 2.66: DPV test run steady state data .....	76
Table 2.67: FWE20FWC20 test run steady state data .....	78

## 1.0 Introduction

The data contained in this report is part of a project sponsored by ASHRAE to study faults in chillers. This experimental data is necessary to properly construct simulation models that will be used in the detection and diagnosis of faults in chillers.

The experimental work is an improvement over previous research efforts in one or more of the categories listed below:

- The faults were introduced at multiple levels of severity
- The faults were tested at different operating conditions and chiller loading
- A wide variety of chiller faults were studied
- A complete suite of sensor data was collected from the chiller at a sampling rate that permits transient analysis
- The test unit was representative of a typical building installation

Past research has tended to focus more on developing the fault detection and diagnostics (FDD) method than developing a good database with which to test the accuracy and sensitivity of those methods.

The purpose of this report is to be a reference guide to the data collected during the experimental testing conducted as a part of this project (the data is available on CD-ROM). The data from each fault test can be compared to data taken during a test where the fault was not present. The deviations (or residuals) of the faulty measurements from the normal measurements are then commonly used in various FDD methods. Fault tests at different levels of severity are provided as an aid to determine the method's sensitivity in detecting the given fault.

## 2.0 Test Data from Fault Studies

It is not feasible to present all the data collected in either graph or table form, such an undertaking would require multiple large volumes. Moreover, condensing all the data from one test run into a single time plot would render the information indecipherable. Therefore, each test run is presented only as a table of steady state values of the key variables measured (shown in Table 2.1). The actual test data was sampled at 10 second

intervals and includes transient data between the steady state operating conditions presented in this report.

**Table 2.1: Definition of terms used in steady state data presentation**

<b>Label</b>	<b>Description</b>	<b>Units</b>
Test	The sequential test number within a given test run	--
TEI	Temperature of entering evaporator water	F
TEO	Temperature of leaving evaporator water	F
TCI	Temperature of entering condenser water	F
TCO	Temperature of leaving condenser water	F
Cond Tons	Heat transfer rate in the condenser	Tons
Evap Tons	Heat transfer rate in the evaporator	Tons
kW	Compressor motor power consumption	kW
FWC	Condenser water flow rate	GPM
FWE	Evaporator water flow rate	GPM
PRE	Evaporator pressure	PSIG
PRC	Condenser pressure	PSIG
TRC_sub	Subcooling	F
T_suc	Suction temperature	F
Tsh_suc	Suction superheat	F
TR_dis	Discharge temperature	F
Tsh_dis	Discharge superheat	F

The steady state information given in this report is meant to be both a quick reference guide as well as a check on the electronic databases (in case file names become damaged or changed). The data from each test run is contained within a separate excel workbook. Within each workbook there are multiple spreadsheets. The first spreadsheet contains all the data collected (Table 2.2 presents all the data exported into the excel workbooks). The second spreadsheet contains the same data, except that the sampling rate has been reduced to once every two minutes instead of once every ten seconds for the complete data set. A third spreadsheet contains a plot of the driving conditions to provide a general overview of how well the test run met the desired operating conditions (this plot is generated from data taken from the reduced data set). The fourth spreadsheet contains a complete listing of steady state data points—this same sheet was abridged for presentation in this report. The fifth spreadsheet contains all the data needed for the regression analysis, and the sixth spreadsheet stores all the results from the regression

analysis. The sixth spreadsheet was then copied into another excel workbook which compares the different fault conditions to a common benchmark test.

For further research efforts, it is recommended that just the original data be used along with any assumptions that are desired (e.g. each researcher will likely have different criteria for whether a given test reached steady state). Care should be taken to ensure that erroneous sensor readings are not used in the data analysis. These readings are obviously wrong and relatively infrequent (less than 0.0001% of all measurements) and may be caused by transmission error. Many of the original erroneous sensor readings were eliminated (by copying the previous time step over them); however, a few of the less crucial erroneous sensor readings may have gone unnoticed and may still be in the data.

**Table 2.2: Exported data from experimental test runs**

<b>Designation</b>	<b>Source</b>	<b>Description</b>	<b>Units</b>
Time	VisSim	Real time counter	Seconds
TWE_set	MicroTech	Chilled water setpoint—control variable	F
TEI	JCI AHU (RTD)	Temperature of Evaporator Water In	F
TWEI	MicroTech (Thermistor)	Temperature of Evaporator Water In	F
TEO	JCI AHU (RTD)	Temperature of Evaporator Water Out	F
TWEO	MicroTech (Thermistor)	Temperature of Evaporator Water Out	F
TCI	JCI AHU (RTD)	Temperature of Condenser Water In	F
TWCI	MicroTech (Thermistor)	Temperature of Condenser Water In	F
TCO	JCI AHU (RTD)	Temperature of Condenser Water Out	F
TWCO	MicroTech (Thermistor)	Temperature of Condenser Water Out	F
TSI	JCI AHU (RTD)	Temperature of Shared HX Water In (in Condenser Water Loop)	F
TSO	JCI AHU (RTD)	Temperature of Shared HX Water Out (in Condenser Water Loop)	F
TBI	JCI AHU (RTD)	Temperature of Building Water In (in Evaporator Water Loop)	F
TBO	JCI AHU (RTD)	Temperature of Building Water Out (in Evaporator Water Loop)	F
Cond Tons	VisSim	Calculated Condenser Heat Rejection Rate	Tons
Cooling Tons	VisSim	Calculated City Water Cooling Rate	Tons
Shared Cond Tons	VisSim	Calculated Shared HX Heat Transfer (only valid with no water bypass)	Tons
Cond Energy Balance	VisSim	Calculated 1 <sup>st</sup> Law Energy Balance for Condenser Water Loop (only valid with no water bypass)	Tons
Evap Tons	VisSim	Calculated Evaporator Cooling Rate	Tons
Shared Evap Tons	VisSim	Calculated Shared HX Heat Transfer (should equal Shared Cond Tons with no water bypass)	Tons
Building Tons	VisSim	Calculated Steam Heating Load	Tons
Evap Energy Balance	VisSim	Calculated 1 <sup>st</sup> Law Energy Balance for Evaporator Water Loop	Tons
kW	JCI AHU	Watt Transducer Measuring Instantaneous Compressor Power	kW
COP	VisSim	Calculated Coefficient of Performance	--
kW/ton	VisSim	Calculated Compressor Efficiency	kW/ton
FWC	JCI AHU	Flow Rate of Condenser Water	GPM
FWE	JCI AHU	Flow Rate of Evaporator Water	GPM
TEA	MicroTech	Evaporator Approach Temperature	F
TCA	MicroTech	Condenser Approach Temperature	F
TRE	MicroTech	Saturated Refrigerant Temperature in Evaporator	F
PRE	MicroTech	Pressure of Refrigerant in Evaporator	PSIG
TRC	MicroTech	Saturated Refrigerant Temperature in Condenser	F
PRC	MicroTech	Pressure of Refrigerant in Condenser	PSIG
TRC_sub	MicroTech	Liquid-line Refrigerant Subcooling from Condenser	F

T_suc	MicroTech	Refrigerant Suction Temperature	F
Tsh_suc	MicroTech	Refrigerant Suction Superheat Temperature	F
TR_dis	MicroTech	Refrigerant Discharge Temperature	F
Tsh_dis	MicroTech	Refrigerant Discharge Superheat Temperature	F
P_lift	MicroTech	Pressure Lift Across Compressor	PSI
Amps	MicroTech	Current Draw Across One Leg of Motor Input	Amps
RLA%	MicroTech	Percent of Maximum Rated Load Amps	%
Heat Balance (kW)	VisSim	Calculated 1 <sup>st</sup> Law Energy Balance for Chiller	kW
Heat Balance%	VisSim	Calculated 1 <sup>st</sup> Law Energy Balance for Chiller	%
Tolerance%	VisSim	Calculated Heat Balance Tolerance According to ARI 550	%
Unit Status	MicroTech	Consult Table B.4 in Appendix	0 – 27
Active Fault	MicroTech	Consult Table B.3 in Appendix	0 – 44
TO_sump	MicroTech	Temperature of Oil in Sump	F
TO_feed	MicroTech	Temperature of Oil Feed	F
PO_feed	MicroTech	Pressure of Oil Feed	PSIG
PO_net	MicroTech	Oil Feed minus Oil Vent Pressure	PSI
TWCD	MicroTech	Condenser Water Temperature Delta	F
TWED	MicroTech	Evaporator Water Temperature Delta	F
VSS	JCI AHU	Small Steam Valve Position	% Open
VSL	JCI AHU	Large Steam Valve Position	% Open
VH	JCI AHU	Hot Water Valve Position	% Open
VM	JCI AHU	3-way Mixing Valve Position	% Mix
VC	JCI AHU	Condenser Valve Position	% Open
VE	JCI AHU	Evaporator Valve Position	% Open
VW	JCI AHU	City Water Valve Position	% Open
TWI	JCI AHU (RTD)	Temperature of City Water In	F
TWO	JCI AHU (RTD)	Temperature of City Water Out	F
THI	JCI AHU (RTD)	Temperature of Hot Water In	F
THO	JCI AHU (RTD)	Temperature of Hot Water Out	F
FWW	VisSim	Calculated City Water Flow Rate	GPM
FWH	VisSim	Calculated Hot Water Flow Rate	GPM
FWB	VisSim	Calculated Condenser Water Bypass Flow Rate	GPM

Moreover, some researchers may find it useful to know exactly what sequence the tests were performed—this information is given in Table 2.3. Many of the tests were performed overnight; however, the date listed is when the test concluded. Several tests were performed more than once due to problems with the initial test run. In many cases the individual tests are still good, it was typically just a couple of the 27 tests that failed to meet the desired operating conditions. Some researchers may find that some of the tests that never reached steady state will provide a wealth of information for transient analysis (the frequency of measurement oscillation as well as the phasing between certain measurements). Finally don't overlook the test marked 'Normal B'. This test is included in the CD-ROM, but is not included in the tables of this report. The reason for giving it such a low profile is because the test run was reversed and all the operating conditions were tested backwards compared to all the other tests ('Normal B' Test 1 equals 'Normal' Test 27, 'Normal B' Test 12 equals 'Normal' Test 16, etc.). During the 'Normal B' test run the chiller shut off twice, both times to allow the chilled water temperature to rise.

**Table 2.3: Sequence of testing and file names**

<b>File name</b>	<b>Date of Test</b>	<b>Comments</b>
Defective Pilot Valve	8/19/99	The last test before the pilot valve was replaced; condenser water flow rate was not corrected
Normal DPV	8/25/99	The first test where the new pilot valve was properly adjusted; condenser water flow rate was not corrected
FWC30	9/2/99	Condenser water flow rate reduced by 30%; was able to perform test with old pump
FWC40	9/3/99	Condenser water flow rate reduced by 40%; was able to perform test with old pump
Near Normal3	9/9/99	The worst of the corrected condenser water flow rate tests; hence it was numbered #3 even though it was the first
Near Normal1	9/10/99	Test run under normal conditions; however, not all the desired operating conditions were met satisfactorily
Near Normal2	9/11/99	Test run under normal conditions; however, not all the desired operating conditions were met satisfactorily
Normal	9/12/99	The first test run where all operating conditions were met
FWC10	9/13/99	Condenser water flow rate reduced by 10%
FWC20 alt	9/14/99	Condenser water flow rate reduced by 20%; not all operating conditions met satisfactorily
FWC20	9/15/99	Condenser water flow rate reduced by 20%
Normal1	9/16/99	Another test under normal conditions; became the reference standard by meeting all the operating conditions exceptionally well
FWE10	9/17/99	Evaporator water flow rate reduced by 10%
FWE20 alt	9/18/99	Evaporator water flow rate reduced by 20%; test number 5 never reached steady state
FWE20	9/18/99	Evaporator water flow rate reduced by 20%; test performed all day long immediately after overnight test run FWE20 alt
FWE30	9/19/99	Evaporator water flow rate reduced by 30%
FWE40 alt	9/20/99	Evaporator water flow rate reduced by 40%; test number 8 never reached steady state
FWE40	9/21/99	Evaporator water flow rate reduced by 40%
Normal2	9/21/99	Another test under normal conditions created for comparison purposes
FWE20FWC20	9/22/99	Evaporator and Condenser water flow rates reduced by 20%; a compound fault
RL40 alt	9/24/99	Refrigerant charge 40% less than nominal; 5 of the 27 tests did not reach steady state
RL40	9/25/99	Refrigerant charge 40% less than nominal
RL30	9/26/99	Refrigerant charge 30% less than nominal
RL20	9/27/99	Refrigerant charge 20% less than nominal
RL10	9/28/99	Refrigerant charge 10% less than nominal
Normal R	9/29/99	Refrigerant charge at nominal (300 lbs)
RO10	9/30/99	Refrigerant charge 10% more than nominal
RO20	10/1/99	Refrigerant charge 20% more than nominal
RO30	10/2/99	Refrigerant charge 30% more than nominal
RO40	10/3/99	Refrigerant charge 40% more than nominal
Normal R1	10/5/99	Refrigerant charge at nominal (300 lbs)
Normal EO	10/6/99	Changed control program to improve ability to reach desired operating conditions

Normal B	10/7/99	Control program reversed so that tests were run in opposite sequence; data compares favorably to other normal test runs but is normally excluded from analysis because test sequence numbers do not match and may therefore cause confusion
EO14	10/8/99	Oil charge 14% more than nominal (added 3.25 lbs of oil, bringing total charge to 25 pounds)
EO32	10/9/99	Oil charge 32% more than nominal (added 4 lbs of oil, bringing total charge to 29 pounds)
EO50	10/10/99	Oil charge 50% more than nominal (added 4 lbs of oil, bringing total charge to 33 pounds)
Aborted EO86	10/11/99	Oil charge 86% more than nominal (added 8 lbs of oil, bringing total charge to 41 pounds); chiller stopped in middle of third test
EO73 alt	10/12/99	Oil charge 73% more than nominal (removed 3 lbs of oil, bringing total charge to 38 pounds); first test never reached steady state
EO68	10/13/99	Oil charge 68% more than nominal (removed 1 lb of oil, bringing total charge to 37 pounds); first test never reached steady state
Normal CF	10/14/99	Oil charge back to normal (21 pounds, 1 less than before); oil pressure regulator turned CW (1/8th turn) boosting oil pressures
CF6	10/15/99	Plugged 10 tubes in the condenser (out of 164)
CF12	10/16/99	Plugged 20 tubes in the condenser
CF20	10/19/99	Plugged 33 tubes in the condenser
CF30	10/20/99	Plugged 49 tubes in the condenser
Normal CF2	10/21/99	Unplugged all the tubes
Normal CF3	10/22/99	Another normal test run; 16th test had about a 5% reduction in condenser water flow
Normal CF4	10/23/99	Another normal test run
Normal CF5	10/24/99	Another normal test run; started soon after the previous one had finished (starting water temperatures were therefore cooler)
Normal CF6	10/25/99	Another normal test run; the fifth in a row
CF45	10/26/99	Plugged 74 tubes in the condenser
Normal NC	10/27/99	Unplugged all the tubes
Aborted NC	10/29/99	Too much Nitrogen (even after trying to purge some); stopped after 10th test due to surge
Modified NC	10/31/99	Modified low load tests to determine if complete test sequence could be completed by eliminating the surge-prone low load tests
NC5	11/3/99	Approximately 0.54 lbs Nitrogen (displacing about 5.6% of the volume at room temperature); could not reach all desired operating conditions
NC3	11/4/99	Approximately 0.22 lbs Nitrogen (displacing about 2.4% of the volume at room temperature)
NC2	11/6/99	Approximately 0.16 lbs Nitrogen (displacing about 1.8% of the volume at room temperature)
NC1	11/7/99	Approximately 0.10 lbs Nitrogen (displacing about 1.0% of the volume at room temperature)
NC Trace	11/8/99	Trace amount of Nitrogen present
NC Trace 2	11/9/99	Trace amount of Nitrogen present (some purged after previous test)

## Normal Tests

Based on the information contained in Table 2.3, it is possible to determine which tests may be appropriately compared. Essentially if any non-repeatable change was made in the system, then data should not be compared across that change. Changes introduced by changing a valve position or plugging condenser tubes does not impact the refrigerant system; therefore, tests performed before or after those faults can be compared.

However, changing oil charge, refrigerant charge, expansion valve and similar events may not permit the unit to return back to its original state after the fault is removed. A list of appropriate benchmark tests to use with a given fault test are provided in Table 2.4.

**Table 2.4: Recommended benchmark tests for each fault tested**

<b>Fault test</b>	<b>Suitable benchmark tests</b>
Reduced Condenser Water Flow	Normal, Normal (1 & 2), Near Normal (1, 2, & 3)
Reduced Evaporator Water Flow	Normal, Normal (1 & 2), Near Normal (1, 2, & 3)
Refrigerant Leak	Normal R, Normal R1, Normal EO
Refrigerant Overcharge	Normal R, Normal R1, Normal EO
Excess Oil	Normal R1, Normal EO
Condenser Fouling	Normal (CF, CF2, CF3, CF4, CF5, & CF6), Normal NC
Non-Condensables in Refrigerant	Normal (CF, CF2, CF3, CF4, CF5, & CF6), Normal NC
Defective Pilot Valve	Normal DPV

**Table 2.5: Near Normal 1 test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.41	50.32	85.52	95.27	106.92	90.84	83.24	263	216	37.66	125.70	9.70	46.80	4.24	123.88	23.24
2	56.99	50.75	85.25	91.29	66.78	55.97	58.18	265	215	38.58	113.10	6.56	48.78	5.44	128.56	33.96
3	53.61	50.27	85.18	88.56	37.46	30.07	42.69	266	216	39.22	105.10	4.58	49.68	5.66	145.34	54.92
4	60.69	49.58	75.68	86.15	116.10	99.87	76.72	266	216	36.20	108.30	9.82	45.70	4.66	113.80	21.80
5	56.50	50.26	75.48	81.38	65.65	55.94	50.24	267	215	37.94	95.30	6.32	48.16	5.38	118.56	33.60
6	53.11	50.46	75.04	77.76	30.37	23.73	35.04	268	215	39.52	85.90	3.48	50.10	5.82	144.26	64.64
7	58.76	49.77	70.69	79.02	92.66	80.83	59.47	267	216	36.90	94.00	7.86	46.76	4.92	109.52	25.52
8	56.01	49.83	65.68	71.33	63.26	55.67	43.10	269	216	36.66	78.60	5.98	47.70	6.30	110.34	35.60
9	53.74	50.14	63.62	67.00	38.15	32.38	34.04	271	216	37.70	70.10	3.84	49.26	6.76	123.36	54.14
10	55.89	46.42	85.58	94.81	101.50	84.92	82.35	264	215	35.68	122.80	8.40	43.76	3.12	123.26	23.90
11	51.20	45.09	85.57	91.61	66.78	54.69	60.08	265	214	35.36	113.60	6.44	43.48	3.26	126.64	31.86
12	48.91	45.41	85.35	89.01	40.64	31.39	45.24	266	216	36.62	106.40	4.84	44.86	3.40	140.16	49.36
13	56.24	45.13	75.59	86.15	117.62	99.48	81.06	267	215	33.68	108.10	9.38	41.82	3.30	113.10	21.04
14	50.53	44.22	75.94	82.03	68.25	56.67	52.83	269	215	34.20	96.20	6.22	42.44	3.30	115.82	30.28
15	48.05	45.13	75.32	78.37	34.46	26.17	36.96	271	215	36.28	86.90	3.54	44.84	3.64	136.32	56.10
16	56.41	45.27	71.44	81.96	116.58	100.16	75.73	266	216	33.42	100.90	9.52	41.78	3.52	108.84	20.76
17	51.44	44.33	65.76	72.42	74.96	63.64	48.93	270	215	33.44	81.10	6.46	42.16	3.90	104.98	28.58
18	48.63	45.20	66.01	69.35	37.58	30.76	34.92	270	215	35.20	73.10	4.04	44.68	4.52	123.18	51.60
19	49.96	40.29	80.60	89.99	103.04	86.51	79.94	263	215	32.14	110.10	7.60	37.52	0.66	116.24	23.30
20	46.59	40.53	80.40	86.46	66.74	54.37	56.67	264	215	32.78	104.10	6.78	39.60	2.12	119.70	29.92
21	43.59	40.05	80.32	84.16	42.28	31.67	43.71	265	214	33.28	96.40	3.52	39.88	1.92	130.88	45.52
22	51.18	40.32	70.78	81.08	114.32	97.64	75.71	267	216	30.88	98.80	9.96	37.62	2.22	107.02	19.96
23	46.14	39.52	70.69	77.04	70.69	59.49	51.42	267	215	31.52	88.10	6.98	38.32	2.24	108.40	27.62
24	43.46	40.07	71.17	74.68	39.19	30.35	38.18	268	215	32.58	81.40	4.02	39.84	2.46	123.94	47.34
25	52.62	40.95	69.65	80.62	121.64	105.00	81.51	266	216	30.92	99.00	10.26	37.86	2.38	107.34	20.26
26	46.50	40.05	63.78	69.99	69.61	57.89	45.74	269	215	31.36	76.60	6.32	38.78	2.84	102.58	28.96
27	43.28	39.95	63.49	66.80	37.27	29.79	34.41	271	215	31.98	69.80	3.70	39.72	3.14	117.56	48.72

Table 2.6: Near Normal 2 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.99	50.83	85.63	95.33	107.28	91.23	84.05	266	215	37.74	126.30	9.90	47.18	4.54	124.28	23.46
2	57.00	50.73	85.27	91.22	66.57	56.43	58.39	268	216	38.44	113.00	6.48	48.72	5.38	128.32	33.88
3	53.41	50.04	85.20	88.58	38.13	30.27	42.90	270	215	39.28	105.00	4.28	49.46	5.40	144.32	53.94
4	61.04	50.03	75.57	85.99	115.02	99.46	76.20	265	217	36.06	107.90	10.00	45.96	5.04	114.12	22.26
5	56.45	50.08	75.59	81.61	66.99	57.27	50.85	267	216	37.54	95.80	6.28	47.88	5.36	118.30	33.12
6	53.27	50.63	75.08	77.82	30.43	23.75	34.98	267	216	39.20	85.80	3.54	50.26	6.34	144.70	65.38
7	59.16	50.08	70.53	78.96	93.46	81.28	60.47	266	215	36.54	93.80	8.08	46.80	5.32	109.78	25.78
8	56.08	50.20	65.33	70.75	60.59	52.78	41.91	268	215	36.98	77.20	5.70	48.28	6.30	110.82	36.88
9	53.37	49.92	62.56	65.80	36.51	30.97	32.81	271	216	37.32	68.10	3.32	49.08	6.90	124.32	56.68
10	54.65	45.41	84.86	93.61	97.67	82.88	79.83	268	215	34.42	121.20	8.70	42.70	3.36	122.64	23.90
11	51.65	45.62	85.36	91.27	66.05	54.21	59.19	268	216	35.34	113.10	6.34	43.98	3.62	127.10	32.46
12	48.81	45.31	85.13	88.76	40.71	31.43	45.06	269	216	36.30	105.60	4.60	44.78	3.44	139.88	49.20
13	56.17	45.20	75.39	85.76	115.36	98.41	79.73	267	215	33.46	107.40	9.34	41.78	3.52	112.82	21.16
14	50.06	44.13	75.05	80.81	64.57	52.97	50.55	269	215	33.92	93.90	5.88	42.50	3.58	116.20	32.10
15	47.96	45.09	75.03	78.01	33.50	25.62	36.61	269	215	36.20	86.40	3.64	44.86	3.70	136.56	56.70
16	55.98	45.13	70.77	81.00	113.42	97.63	73.05	266	216	32.98	98.90	9.26	41.54	3.68	108.32	21.44
17	51.12	44.04	65.40	72.00	74.14	63.59	48.50	270	216	33.44	80.30	6.58	41.90	3.68	104.62	28.60
18	48.40	44.92	65.59	68.97	37.87	31.12	34.83	270	215	34.84	72.60	3.82	44.36	4.54	122.66	51.50
19	50.16	40.50	80.50	89.71	102.56	86.36	79.56	267	215	32.18	109.60	7.30	38.26	1.34	116.14	23.54
20	46.82	40.75	80.35	86.37	67.58	54.26	56.77	270	215	32.36	103.40	6.48	39.64	2.58	119.82	30.34
21	43.70	40.17	80.27	84.02	42.01	31.59	43.82	270	215	33.00	96.80	3.80	39.90	2.24	131.14	45.42
22	53.06	41.45	70.78	82.11	122.56	104.18	82.36	260	215	31.30	101.50	10.30	38.48	2.60	109.12	20.60
23	45.85	39.16	70.69	77.12	71.89	59.91	51.78	269	215	31.62	88.00	7.14	37.92	1.72	107.76	26.90
24	43.79	40.47	70.79	74.22	38.55	29.65	37.69	270	215	32.66	80.80	4.12	40.12	2.84	124.72	48.52
25	49.89	39.91	66.12	75.45	104.26	89.70	64.97	268	216	30.42	88.50	9.32	37.42	2.46	102.14	21.36
26	47.27	40.40	65.20	71.74	72.96	61.54	48.81	268	215	30.92	79.80	6.64	38.58	3.06	103.38	27.74
27	43.59	40.13	64.78	68.37	40.14	30.88	35.60	269	215	32.40	72.20	4.20	39.86	2.70	117.24	46.52

Table 2.7: Near Normal 3 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.58	50.33	85.63	95.59	108.94	92.07	83.53	262	216	38.36	125.90	9.52	47.16	3.92	123.26	22.40
2	57.00	50.82	85.34	91.41	66.63	55.51	57.88	264	215	39.20	113.00	6.52	49.02	4.98	128.08	33.50
3	53.34	50.07	85.29	88.66	37.25	29.53	42.32	265	217	39.78	104.70	4.16	49.62	5.00	144.92	54.74
4	60.34	49.03	75.86	86.60	118.60	101.84	78.73	265	216	36.36	109.10	9.74	45.38	4.20	113.62	21.12
5	56.61	50.35	75.58	81.50	66.20	56.05	50.22	269	215	37.98	95.00	6.10	48.30	5.46	118.56	33.66
6	53.06	50.33	75.33	78.09	31.01	24.47	35.23	270	215	39.28	85.90	3.54	50.08	5.98	143.32	63.90
7	59.24	49.98	71.20	79.87	96.65	83.43	61.60	268	216	36.90	95.40	8.20	46.84	5.04	110.02	25.00
8	56.28	50.24	65.78	71.35	62.47	54.36	42.82	269	216	37.08	78.44	5.66	48.26	6.32	110.66	36.10
9	53.75	49.89	64.13	67.73	40.76	34.77	34.76	272	216	37.78	71.10	4.22	49.06	6.46	121.14	45.96
10	55.58	46.06	85.63	94.97	102.38	85.96	82.75	263	217	35.70	124.30	8.68	43.76	3.08	123.00	23.00
11	51.64	45.63	85.61	91.61	66.34	54.10	59.39	265	216	35.98	113.70	6.46	44.24	3.32	126.92	32.10
12	48.54	45.13	85.35	89.07	41.14	30.72	45.29	266	216	36.90	106.40	4.70	44.76	2.92	139.94	48.80
13	57.53	46.15	77.28	88.30	121.70	102.50	85.82	265	216	34.38	112.80	9.70	42.80	3.44	115.82	21.56
14	50.90	44.60	76.00	82.15	68.74	56.67	52.53	268	216	35.22	96.70	6.22	43.24	3.06	115.88	30.16
15	48.04	45.05	75.48	78.64	35.48	26.89	37.64	269	216	36.38	87.50	4.00	44.84	3.60	135.12	54.42
16	55.78	44.71	71.20	81.58	115.40	99.70	73.98	267	216	33.68	100.20	9.26	41.74	3.16	108.24	20.62
17	51.33	44.12	65.76	72.47	75.82	64.88	49.21	271	216	33.76	81.10	6.54	42.12	3.56	104.58	28.12
18	48.57	45.13	66.05	69.42	38.03	30.92	35.15	271	216	35.34	73.90	3.88	44.76	4.32	122.58	51.00
19	51.14	41.28	81.09	90.61	105.16	88.53	81.05	265	216	32.78	115.52	9.48	38.76	1.18	117.02	21.48
20	46.40	40.18	80.40	86.53	67.99	55.82	56.76	266	215	33.10	103.60	6.64	39.20	1.32	118.02	28.52
21	43.70	40.15	80.37	84.20	42.65	31.85	43.64	267	215	33.62	96.00	3.30	39.94	1.56	130.22	44.82
22	51.45	40.46	71.14	81.48	115.22	98.54	76.50	268	215	31.28	99.60	10.08	37.90	2.06	107.06	19.88
23	46.33	39.19	71.68	78.52	76.76	64.07	54.22	269	215	31.74	90.56	7.22	37.92	1.54	107.46	25.32
24	43.57	40.20	71.54	75.10	39.96	30.15	38.00	269	215	33.28	81.20	3.28	40.08	2.08	123.32	46.96
25	53.02	41.26	70.12	81.20	123.18	105.96	82.39	267	216	31.38	100.00	10.56	38.36	2.32	107.88	20.20
26	46.57	40.17	63.67	69.80	68.84	57.26	45.53	269	215	31.40	76.40	6.42	38.82	2.80	102.42	29.10
27	43.32	40.10	63.23	66.49	36.88	28.84	33.94	271	215	32.70	69.00	3.64	39.90	2.44	117.58	49.18

**Table 2.8: Normal test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.44	50.42	85.46	95.01	105.76	90.12	83.63	266	216	37.18	125.60	10.00	46.76	4.72	124.42	23.84
2	56.96	50.76	85.19	91.08	65.54	55.75	57.58	267	216	38.14	112.60	6.46	48.72	5.62	128.88	34.48
3	53.76	50.42	85.16	88.49	37.19	29.90	42.55	269	215	38.96	104.80	4.56	49.76	5.88	145.58	55.08
4	61.07	50.08	75.54	85.93	114.70	98.89	76.12	265	216	35.78	108.20	10.14	45.98	5.22	114.22	22.34
5	56.42	50.20	75.31	81.24	65.86	55.75	50.40	266	215	37.56	95.20	6.40	48.08	5.62	118.90	34.02
6	53.05	50.32	75.15	77.95	31.06	24.47	35.13	267	216	39.24	86.00	3.52	50.08	6.08	143.08	63.64
7	59.14	49.93	70.57	79.11	94.74	82.82	60.65	266	216	35.88	94.00	8.10	46.60	5.72	109.98	25.90
8	55.99	49.90	65.29	70.89	62.53	54.67	42.47	268	215	36.90	77.80	5.80	47.84	5.96	110.22	35.94
9	53.63	50.35	62.39	65.49	34.81	29.52	32.29	269	216	37.74	67.60	3.30	49.58	6.86	125.42	58.14
10	55.08	45.79	85.00	93.87	98.77	83.29	80.63	267	215	34.68	121.90	8.66	42.94	3.32	122.72	23.84
11	51.94	45.77	85.40	91.45	67.57	55.29	59.90	268	215	35.34	113.50	6.46	44.06	3.72	126.78	32.26
12	48.82	45.24	85.19	88.87	41.14	32.10	45.33	269	215	36.14	105.90	4.48	44.76	3.76	139.58	48.82
13	56.19	45.33	75.20	85.50	114.54	97.52	79.08	267	215	33.32	106.90	9.50	41.82	3.70	112.64	21.30
14	50.69	44.71	74.97	80.74	64.53	53.72	50.32	268	215	34.20	94.00	6.04	42.96	3.94	116.58	32.32
15	48.10	45.26	74.90	77.85	33.04	25.43	36.41	269	215	35.92	86.10	3.62	45.04	4.20	137.20	57.38
16	55.63	45.22	70.04	79.75	107.66	93.45	69.19	266	216	33.08	96.40	9.04	41.78	3.96	107.34	21.82
17	51.00	44.29	64.47	70.69	69.92	60.18	46.12	270	215	32.94	77.88	6.46	42.08	4.42	105.02	30.50
18	48.13	44.87	64.68	67.90	36.25	29.24	33.79	270	215	35.10	71.20	3.86	44.42	4.34	123.20	53.34
19	50.01	40.44	79.94	89.03	101.01	85.85	77.65	267	215	32.14	109.00	7.68	37.96	1.26	115.10	22.80
20	46.71	40.57	80.13	86.14	67.34	54.99	56.73	269	215	32.50	103.70	6.60	39.50	2.28	119.20	29.76
21	43.89	40.38	80.10	83.83	42.08	31.45	43.29	271	215	33.32	96.10	3.94	40.18	2.04	131.36	45.84
22	51.41	40.51	69.71	79.91	113.36	97.67	74.82	267	215	30.68	97.00	9.64	37.78	2.50	106.18	20.26
23	45.72	39.37	69.32	75.45	68.94	56.67	49.42	270	214	31.60	85.10	6.78	38.28	2.16	107.46	28.30
24	43.21	40.03	69.26	72.62	38.08	28.33	36.53	271	214	32.56	78.26	3.84	39.86	2.64	123.94	49.36
25	50.08	40.14	66.01	75.26	103.52	88.90	64.79	269	215	30.52	88.10	9.26	37.64	2.58	102.22	21.22
26	47.20	40.33	65.03	71.54	72.81	61.57	48.61	268	215	31.38	79.50	6.72	38.82	2.94	103.08	27.54
27	43.65	40.05	65.04	68.76	41.86	32.14	36.27	269	215	32.48	72.80	4.46	39.80	2.54	115.88	44.80

**Table 2.9: Normal 1 test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.60	50.40	85.60	95.31	107.50	91.95	85.18	266	216	37.28	126.50	10.18	46.80	4.62	124.82	23.72
2	57.07	50.76	85.28	91.23	66.62	56.68	58.19	269	216	38.16	112.90	6.52	48.64	5.60	128.68	34.20
3	53.60	50.27	85.12	88.44	37.09	29.83	42.50	269	215	39.28	104.70	4.50	49.72	5.66	145.64	55.30
4	61.27	50.37	75.48	85.76	113.28	98.22	75.34	264	216	35.88	107.60	10.10	46.28	5.48	114.38	22.70
5	56.58	50.51	74.90	80.65	63.92	54.34	48.97	267	215	37.46	93.80	6.12	48.38	6.08	119.20	35.20
6	52.68	49.95	75.15	77.98	31.41	24.50	35.30	267	215	38.86	85.90	3.28	49.72	6.10	142.96	63.42
7	58.45	49.47	69.98	78.34	92.66	80.72	58.81	266	216	36.10	92.60	8.18	46.34	5.40	109.32	25.98
8	55.95	49.86	65.34	70.89	61.80	54.64	42.66	267	215	36.10	77.68	5.94	47.72	6.70	110.54	36.38
9	53.49	50.10	62.52	65.70	35.76	30.46	32.70	270	216	37.08	67.60	3.46	49.30	7.18	125.12	57.60
10	56.16	46.83	85.27	94.14	98.81	83.83	81.08	267	216	35.08	120.40	7.78	43.66	3.66	123.58	25.44
11	51.30	45.24	85.30	91.14	65.39	54.40	59.16	269	215	35.18	112.70	6.30	43.60	3.46	127.10	32.70
12	49.18	45.77	84.95	88.48	39.67	30.68	44.39	270	216	36.18	105.30	4.60	45.22	4.08	140.82	50.40
13	55.95	45.09	75.23	85.53	114.46	97.41	79.34	267	215	32.96	107.00	9.66	41.42	3.70	113.02	21.60
14	50.21	44.14	75.21	81.12	66.19	54.35	51.26	269	215	34.24	94.40	6.16	42.46	3.34	115.88	31.64
15	48.34	45.49	75.03	78.00	33.22	25.59	36.55	269	215	36.02	86.10	3.56	45.26	4.26	137.30	57.88
16	55.50	44.84	70.23	80.27	111.58	95.62	71.34	267	215	32.70	97.30	9.12	41.28	4.00	107.72	21.58
17	51.28	44.39	64.96	71.30	71.20	61.71	47.09	270	215	32.90	79.00	6.28	42.16	4.60	105.34	30.28
18	48.52	45.30	64.76	67.92	35.50	28.75	33.57	270	214	35.02	71.20	3.70	44.84	4.84	124.46	54.62
19	50.00	40.38	80.11	89.24	101.80	86.15	78.94	267	215	31.98	108.80	7.14	37.92	1.30	115.84	23.40
20	46.48	40.35	80.03	86.06	67.53	54.84	56.61	269	215	32.66	103.40	6.70	39.38	1.98	119.10	29.62
21	44.08	40.46	80.11	83.87	42.42	32.28	44.09	270	215	32.88	97.20	4.48	40.02	2.52	131.68	45.62
22	51.84	40.39	70.16	81.01	120.36	102.76	81.04	266	215	30.48	99.50	10.02	37.42	2.44	107.92	20.74
23	45.55	39.16	69.26	75.43	69.32	57.25	49.66	269	215	31.18	85.20	6.64	37.96	2.32	107.38	28.38
24	43.55	40.51	68.25	71.39	35.31	27.17	35.21	270	215	32.96	76.30	3.74	40.28	2.60	125.08	51.80
25	48.64	39.42	63.36	71.91	95.55	82.69	58.45	268	215	30.50	81.90	8.56	37.34	2.22	99.68	22.74
26	45.88	40.12	61.14	66.52	60.39	51.52	41.59	269	215	30.62	71.00	5.42	38.74	3.62	102.34	32.64
27	43.02	40.13	60.83	63.85	34.02	25.82	31.95	270	215	32.16	65.30	3.14	39.88	3.12	119.16	53.46

**Table 2.10: Normal 2 test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	61.64	51.69	85.67	95.13	104.86	89.57	83.66	266	216	36.94	122.70	8.84	47.66	5.84	126.54	27.14
2	56.95	50.67	85.33	91.34	67.34	56.70	58.57	269	216	37.48	113.30	6.80	48.30	6.02	129.24	34.62
3	53.98	50.73	85.21	88.50	37.06	29.33	42.53	270	216	38.96	104.90	4.70	50.02	6.30	146.74	56.40
4	61.27	50.04	75.83	86.54	118.26	101.08	78.78	265	216	35.80	109.50	10.44	45.82	5.12	115.02	22.28
5	56.93	50.58	75.81	81.81	66.86	57.16	50.93	267	216	37.40	95.90	6.42	48.28	5.98	119.04	33.76
6	53.12	50.40	75.36	78.17	31.20	24.45	35.33	267	216	38.70	86.20	3.54	50.06	6.54	143.84	63.96
7	59.22	50.07	70.77	79.29	94.41	82.35	61.00	266	216	35.98	94.20	8.26	46.68	5.68	110.34	26.06
8	56.14	49.91	65.84	71.59	64.03	56.00	43.64	267	216	36.52	78.80	6.04	47.72	6.20	110.14	35.12
9	53.82	49.94	64.55	68.25	41.42	34.94	35.08	269	216	37.18	72.10	4.04	48.92	6.82	121.94	51.34
10	55.35	46.29	85.33	94.05	97.17	81.40	79.68	267	216	34.56	122.00	8.78	43.24	3.82	123.94	25.02
11	51.32	45.08	85.76	91.82	67.59	56.16	60.73	268	216	34.58	114.10	6.66	43.24	3.82	127.40	32.30
12	48.69	45.17	85.33	88.94	40.36	31.54	45.03	268	215	35.60	106.10	4.64	44.58	4.02	140.62	49.82
13	56.54	45.55	75.93	86.40	116.08	99.06	81.51	266	216	33.42	109.00	9.76	41.90	3.70	113.96	21.50
14	50.05	44.06	75.72	81.53	65.09	53.72	51.37	269	215	33.74	95.50	6.10	42.34	3.76	116.78	31.72
15	48.11	45.15	75.56	78.65	34.60	26.67	37.27	269	216	35.88	87.40	3.84	44.84	4.06	136.32	55.74
16	55.31	44.83	70.77	80.71	110.28	94.33	70.83	266	216	32.88	97.90	8.98	41.44	3.82	108.10	21.76
17	51.28	44.07	65.74	72.42	74.87	64.75	49.07	269	216	32.48	81.00	6.46	41.70	4.42	105.42	29.06
18	48.69	45.40	65.76	68.99	36.23	29.48	34.13	269	215	35.00	72.50	3.58	44.90	4.84	124.48	53.58
19	50.10	40.87	80.70	89.56	98.98	83.04	77.60	268	216	31.70	112.90	8.38	38.86	2.52	117.36	22.94
20	46.70	40.68	80.28	86.25	66.80	53.97	56.80	269	215	31.94	103.90	6.22	39.44	2.82	120.20	30.48
21	43.67	40.17	80.21	83.91	41.56	31.23	43.48	270	215	32.70	97.00	4.68	39.88	2.48	132.48	46.70
22	51.87	40.63	70.74	81.43	117.92	100.92	80.47	265	215	30.42	100.10	9.74	37.56	2.74	108.44	21.04
23	45.86	39.17	71.18	77.59	71.53	59.98	52.35	268	215	31.20	89.20	6.92	37.96	2.12	108.40	26.88
24	43.38	39.99	71.24	74.78	39.68	30.51	38.12	269	216	32.78	81.20	3.82	39.86	2.48	123.96	47.40
25	50.18	40.23	66.56	75.93	104.08	89.15	65.52	267	215	30.46	89.20	9.18	37.74	2.90	102.64	21.16
26	47.56	40.57	65.92	72.54	73.77	62.57	49.53	267	215	30.60	81.10	6.40	38.62	3.48	104.22	28.04
27	43.58	39.97	65.60	69.30	41.33	32.53	36.31	269	216	32.02	73.40	4.20	39.60	2.98	117.10	45.66

**Table 2.11: Normal R test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	59.93	50.46	85.32	94.32	100.10	85.12	78.80	267	216	37.16	125.30	10.62	47.24	5.28	124.92	24.56
2	57.03	50.73	85.54	91.54	67.25	56.76	59.23	269	216	37.78	114.80	7.40	48.76	6.08	129.98	34.70
3	53.78	50.34	85.87	89.25	37.99	30.93	43.41	270	216	38.78	107.60	5.12	49.76	6.10	146.50	54.86
4	60.57	50.22	75.87	85.58	107.92	93.08	72.01	267	216	36.56	107.60	10.32	46.80	5.38	114.86	23.20
5	56.42	50.05	76.17	82.24	67.39	57.31	51.34	267	216	37.28	97.20	6.76	48.12	5.94	119.92	33.92
6	52.89	50.07	76.03	78.91	32.22	25.31	36.01	268	216	38.86	88.70	3.94	49.82	6.16	143.42	62.22
7	59.40	49.87	71.54	80.38	98.56	85.66	63.25	268	216	35.88	96.90	8.98	46.72	5.92	111.26	25.38
8	56.27	49.88	66.24	72.08	65.51	57.35	44.28	269	215	36.32	80.40	6.66	47.76	6.50	110.86	34.90
9	53.95	50.09	64.23	67.83	40.64	34.62	34.74	271	216	36.78	71.60	4.40	49.10	7.38	122.98	52.62
10	55.15	45.98	85.28	94.06	98.25	82.49	80.33	269	216	34.88	122.70	9.46	43.36	3.38	123.58	24.24
11	51.92	45.71	86.14	92.17	67.93	55.74	61.31	270	216	35.10	115.72	7.04	43.98	3.90	128.26	32.46
12	48.99	45.41	85.71	89.36	41.31	32.20	45.65	271	216	36.18	107.30	4.88	44.94	3.92	141.18	49.58
13	56.55	45.93	75.90	85.92	111.76	95.80	78.20	267	216	33.58	108.90	10.38	42.40	4.00	113.98	21.66
14	50.78	44.60	76.15	82.08	66.71	55.63	52.30	270	216	34.00	96.90	6.56	42.86	4.02	117.64	31.84
15	48.38	45.40	75.81	78.80	33.61	26.67	37.21	271	215	36.32	88.10	4.06	45.22	4.02	137.34	56.46
16	56.16	45.79	70.74	80.39	108.16	93.30	70.37	269	216	33.34	98.30	9.74	42.30	4.16	108.68	22.08
17	51.29	44.58	66.18	72.22	69.17	60.49	47.13	275	217	33.08	80.80	6.38	42.54	4.66	107.06	31.12
18	48.78	45.31	66.19	69.57	38.15	31.15	35.11	271	215	35.10	74.00	3.96	44.80	4.64	124.08	51.96
19	50.81	41.41	81.13	90.09	100.40	84.28	78.77	269	215	32.40	114.86	9.06	39.44	2.46	117.98	22.72
20	46.59	40.29	81.01	87.17	69.39	56.56	58.08	271	216	32.64	105.50	6.86	39.42	2.02	119.62	29.02
21	43.63	40.09	80.80	84.59	42.71	31.68	43.86	271	215	33.36	97.00	3.34	39.90	1.72	130.96	45.40
22	52.34	41.34	71.06	81.26	114.86	98.65	77.78	270	215	31.00	100.30	10.02	38.50	3.14	108.34	20.52
23	46.37	39.76	71.07	77.32	70.36	59.18	52.03	270	215	30.94	89.20	6.94	38.40	2.92	109.36	27.92
24	43.53	40.29	70.97	74.33	38.06	29.09	37.34	271	215	32.78	81.40	4.18	39.98	2.44	125.52	48.96
25	50.87	40.64	67.57	77.10	106.86	91.86	67.94	269	215	30.58	91.80	9.52	38.16	3.08	104.18	21.26
26	47.19	40.09	66.23	72.97	75.70	63.56	50.31	269	215	31.22	82.50	7.26	38.50	2.66	104.18	26.78
27	43.65	39.98	66.13	69.85	41.81	32.86	36.85	269	215	32.22	75.00	4.68	39.52	2.46	117.06	44.36

Table 2.12: Normal R1 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.88	51.26	85.45	94.56	100.80	86.44	78.76	266	215	37.20	124.20	10.26	47.78	5.64	124.96	25.04
2	55.77	49.49	85.44	91.44	67.09	56.29	58.57	268	215	37.76	113.60	6.90	47.56	4.86	128.30	33.60
3	53.90	50.62	85.85	89.16	37.06	29.51	42.32	269	216	39.68	106.00	4.52	50.08	5.62	146.50	55.68
4	60.93	50.69	75.90	85.62	107.22	91.97	71.11	265	215	36.48	106.40	9.74	46.96	5.64	114.64	23.56
5	56.28	49.99	76.30	82.39	67.27	56.62	50.67	265	216	37.26	96.00	6.08	47.92	5.80	119.38	34.12
6	53.01	50.22	76.02	78.79	30.71	24.98	35.32	266	215	37.74	87.40	3.70	49.80	7.08	145.00	64.52
7	58.78	49.48	71.14	79.78	95.53	83.73	60.91	265	216	36.14	94.30	7.88	46.36	5.30	110.18	25.72
8	56.28	49.93	66.31	72.18	65.39	57.02	43.94	267	215	36.22	79.40	5.76	47.74	6.56	110.42	35.06
9	53.93	49.89	65.12	68.90	42.35	36.26	35.41	269	215	37.28	72.40	4.06	48.84	6.76	120.86	49.86
10	54.82	45.78	85.04	93.65	96.19	81.41	77.34	268	216	34.64	119.10	7.88	43.04	3.48	122.28	24.76
11	50.61	44.47	85.84	91.84	67.07	55.21	60.16	269	216	34.88	113.60	6.14	42.92	2.92	126.54	31.80
12	48.64	45.16	85.51	89.12	40.60	31.19	44.67	270	215	36.26	105.70	4.44	44.64	3.44	140.24	49.52
13	56.80	46.02	76.12	86.44	114.76	97.17	79.00	267	216	33.66	108.40	9.86	42.48	3.96	113.70	21.62
14	52.70	45.67	76.20	82.94	75.21	62.88	55.45	268	215	34.48	97.90	6.50	43.44	4.04	115.14	28.70
15	48.29	45.36	75.76	78.74	33.28	26.18	36.75	269	214	36.42	87.40	3.52	45.22	3.98	137.56	57.28
16	55.22	45.51	69.95	79.05	101.26	87.18	64.93	267	215	33.36	93.60	8.28	42.32	4.12	107.26	23.22
17	50.75	44.06	66.40	72.64	70.94	60.02	46.99	273	215	33.08	80.40	5.86	41.98	4.10	106.26	30.30
18	48.73	45.34	66.50	69.88	37.84	30.36	34.77	269	215	35.52	73.60	3.50	44.90	4.32	124.24	52.54
19	49.74	40.59	80.70	89.43	97.43	82.16	75.04	268	215	32.18	112.10	8.46	38.68	1.84	116.00	22.12
20	47.20	41.20	80.99	86.91	66.42	53.66	56.50	269	214	32.52	104.30	5.90	39.98	2.78	120.64	30.74
21	44.20	40.68	80.90	84.62	41.92	31.41	43.58	270	215	33.46	97.40	3.60	40.42	2.12	132.30	46.42
22	51.68	40.76	70.33	80.72	115.22	98.10	74.88	266	216	31.14	97.20	9.48	38.22	2.54	106.54	20.52
23	45.92	39.64	69.98	76.01	67.73	56.16	48.85	270	215	31.36	85.60	6.08	38.46	2.56	108.10	28.78
24	43.19	40.09	69.98	73.25	36.67	27.73	36.05	270	215	32.82	78.50	3.34	39.90	2.40	124.90	50.18
25	48.81	39.79	63.96	72.42	94.42	80.85	57.36	268	215	30.64	81.80	8.06	37.72	2.56	100.22	23.16
26	46.73	40.17	64.80	71.12	70.56	58.88	46.55	268	216	31.64	77.98	5.98	38.90	2.72	103.08	28.80
27	43.31	39.88	64.55	68.11	39.84	30.71	34.18	269	214	32.28	70.50	3.42	39.56	2.64	117.34	47.52

Table 2.13: Normal EO test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	59.84	50.47	85.02	93.92	98.50	84.36	76.24	266	216	37.22	122.00	9.66	47.22	5.10	123.44	24.52
2	55.88	49.54	85.20	91.20	66.93	56.84	58.17	268	215	37.46	112.80	6.68	47.70	5.30	127.96	33.64
3	53.91	50.59	85.37	88.71	37.40	29.75	42.42	269	215	39.28	105.10	4.66	50.02	5.94	146.64	56.02
4	60.56	50.58	74.98	84.35	103.30	89.55	68.53	265	216	36.30	104.40	9.70	47.00	5.76	114.00	24.08
5	56.95	50.76	75.81	81.62	64.68	55.68	50.07	267	216	37.58	94.80	6.20	48.74	6.36	119.70	35.18
6	52.94	50.16	75.78	78.57	31.09	24.85	35.21	267	215	38.82	86.80	3.58	49.96	6.22	143.98	63.74
7	58.14	49.44	69.10	77.23	90.16	78.32	56.47	266	216	35.56	89.70	7.78	46.42	5.78	109.04	27.44
8	55.99	49.76	65.55	71.27	63.89	55.81	42.83	268	215	35.86	78.16	5.76	47.66	6.86	110.54	36.00
9	53.65	50.14	63.09	66.35	36.62	31.51	32.74	270	215	37.12	68.40	3.28	49.30	7.42	124.68	56.72
10	53.30	45.52	79.33	86.64	82.41	69.96	61.96	270	216	34.72	105.40	7.18	43.20	3.50	116.24	25.58
11	51.04	45.03	85.20	91.04	65.38	54.01	59.39	269	216	34.68	112.00	6.26	43.40	3.86	126.86	33.16
12	48.90	45.41	85.15	88.70	39.90	31.15	44.42	270	214	36.10	105.20	4.52	44.98	4.14	140.76	50.40
13	56.39	45.83	75.55	85.59	111.46	94.75	76.60	266	215	33.58	106.70	9.62	42.26	3.96	112.70	21.60
14	50.87	44.15	75.45	81.92	72.40	60.31	53.73	269	215	34.12	95.60	5.98	42.32	3.36	114.00	28.78
15	48.12	45.22	75.28	78.25	33.51	25.99	36.35	270	215	36.14	86.40	3.52	45.02	3.98	137.16	57.42
16	52.93	43.89	66.50	75.02	95.05	81.15	57.89	268	215	33.00	85.90	7.66	41.20	3.42	104.02	24.48
17	51.70	45.14	66.32	72.35	68.07	58.78	46.00	271	215	33.46	79.80	5.92	43.04	4.78	107.38	31.86
18	48.59	45.16	66.33	69.77	38.47	30.77	34.82	269	215	35.22	73.50	3.62	44.68	4.40	123.54	51.94
19	49.19	40.15	80.41	89.00	96.04	81.11	73.35	268	215	31.98	110.80	8.30	38.30	1.60	115.18	22.06
20	46.43	40.18	81.07	87.15	68.31	56.01	57.27	270	215	32.44	104.50	6.50	39.20	2.10	119.36	29.22
21	44.04	40.54	80.62	84.30	41.31	31.29	43.59	269	214	32.86	97.20	4.14	40.16	2.52	132.96	47.06
22	52.07	41.12	70.64	81.02	115.14	98.39	76.47	266	216	30.76	98.30	9.22	38.26	2.96	107.40	20.80
23	46.09	39.50	70.97	77.28	70.83	58.90	50.99	269	214	31.46	87.80	6.54	38.32	2.24	108.52	27.64
24	43.47	40.28	70.31	73.64	37.43	28.50	36.18	270	215	32.60	79.00	3.34	39.98	2.66	125.22	50.00
25	49.70	40.06	65.28	74.25	100.03	86.37	61.96	268	215	30.20	85.60	8.28	37.66	3.08	101.38	22.14
26	46.73	40.14	64.80	71.11	70.41	58.90	46.70	268	215	31.12	78.16	5.98	38.66	3.14	103.22	28.66
27	43.39	39.90	64.60	68.19	40.18	31.29	35.13	268	215	31.98	71.20	3.78	39.40	2.90	116.94	46.76

Table 2.14: Normal CF test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	61.12	51.49	85.63	94.79	101.64	86.69	80.70	266	216	36.76	125.30	10.50	47.38	5.64	125.74	25.06
2	56.26	49.98	85.58	91.59	67.49	56.19	59.71	270	215	36.28	114.40	7.42	47.38	6.12	129.80	34.80
3	53.52	50.20	85.80	89.14	37.64	29.78	42.90	270	215	38.58	106.40	4.78	49.46	5.96	146.34	55.42
4	60.78	50.53	75.89	85.62	107.40	92.21	71.87	265	216	35.68	107.50	10.56	46.30	5.70	115.10	23.56
5	56.40	50.06	76.34	82.40	67.37	56.87	51.30	267	215	35.84	97.00	6.70	47.42	6.58	120.24	34.24
6	53.34	50.60	76.08	78.87	30.96	24.60	35.68	267	215	38.52	87.60	3.66	50.04	6.68	144.78	64.16
7	58.70	49.38	71.06	79.75	96.11	83.69	61.70	266	216	34.84	95.30	8.84	45.56	5.72	110.62	25.88
8	56.47	50.22	66.27	72.05	64.57	56.04	43.68	268	215	35.96	79.20	5.90	47.74	6.84	110.82	35.60
9	53.97	50.13	64.67	68.30	40.84	34.45	34.65	270	215	37.02	72.00	3.98	49.00	7.12	122.66	52.20
10	55.96	47.01	85.18	93.70	95.46	80.35	77.68	269	215	34.70	121.00	9.38	43.76	4.16	124.12	25.72
11	50.46	44.28	85.92	91.96	67.76	55.36	60.91	269	215	34.34	114.20	6.52	42.54	3.36	127.00	31.84
12	49.19	45.82	85.21	88.71	39.28	30.16	44.70	270	215	35.98	105.20	4.50	45.26	4.38	141.74	51.28
13	56.92	46.30	76.09	86.26	112.96	95.52	78.33	267	216	33.22	108.80	10.42	42.26	4.32	114.10	21.92
14	52.01	45.14	76.19	82.81	73.85	61.63	55.06	268	215	33.92	98.00	6.58	42.86	4.04	115.48	29.12
15	48.14	45.19	75.82	78.83	33.67	26.38	37.00	269	214	36.06	87.50	3.58	44.96	4.08	137.00	56.60
16	54.92	44.89	70.05	79.39	103.64	89.97	66.48	266	215	32.74	95.10	8.74	41.40	3.94	107.14	22.50
17	51.83	45.32	66.44	72.45	67.83	58.43	45.89	271	215	33.14	80.30	5.90	43.04	5.14	108.12	32.30
18	48.71	45.30	66.43	69.82	37.96	30.58	34.44	269	216	34.72	73.30	3.50	44.68	5.02	124.22	52.74
19	49.93	41.08	80.43	88.91	95.02	79.02	74.91	269	214	30.64	111.20	8.40	38.40	3.22	117.58	23.96
20	46.76	40.61	81.01	87.03	67.69	55.02	57.07	270	215	32.56	104.40	6.20	39.56	2.34	119.70	29.62
21	44.14	40.70	80.22	83.88	41.07	30.75	43.00	269	215	32.82	96.50	4.34	40.30	2.78	133.08	47.42
22	51.40	40.90	69.69	79.59	109.78	94.11	72.21	266	215	30.08	95.60	8.74	37.74	3.36	106.14	21.06
23	45.69	39.43	69.64	75.72	68.28	55.96	49.08	269	214	30.52	85.30	5.98	37.92	2.82	108.20	29.04
24	43.39	40.45	69.23	72.37	35.37	26.23	35.11	270	214	32.88	77.28	3.20	40.30	2.68	126.04	52.06
25	49.32	40.15	64.51	73.14	96.40	82.23	59.23	268	215	30.54	83.60	8.00	37.82	2.80	100.86	22.78
26	46.82	40.33	64.69	70.90	69.41	57.92	46.27	268	214	31.06	77.70	5.68	38.74	3.26	103.34	29.22
27	44.03	40.72	64.09	67.43	37.38	29.62	34.15	269	214	31.46	70.40	3.72	40.20	4.12	119.42	50.10

Table 2.15: Normal CF2 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.81	51.02	86.05	95.46	104.28	87.92	83.35	266	215	37.02	123.10	8.96	47.04	5.16	126.18	26.74
2	56.01	49.77	85.54	91.53	66.94	55.90	58.83	268	215	37.48	113.90	7.16	47.54	5.14	128.88	33.98
3	53.53	50.23	85.81	89.11	37.05	29.45	42.79	269	215	39.18	106.10	4.94	49.48	5.62	146.26	55.10
4	60.66	50.35	75.92	85.71	107.98	92.70	72.37	265	216	35.78	107.40	10.34	46.26	5.50	114.94	23.40
5	56.67	50.40	76.36	82.40	66.79	56.16	50.86	266	215	37.08	96.80	6.32	48.04	6.02	119.90	34.42
6	52.74	50.00	76.09	78.91	31.26	24.66	35.71	267	216	38.80	87.50	3.54	49.56	5.94	143.20	62.74
7	59.24	49.87	71.63	80.43	97.34	84.17	62.53	265	216	35.40	96.40	8.80	46.10	5.76	111.10	25.54
8	56.35	49.97	66.42	72.34	66.15	57.26	44.42	268	215	35.72	80.00	6.16	47.42	6.70	110.58	34.90
9	53.48	49.96	63.36	66.66	37.06	31.51	33.33	270	215	37.20	69.30	3.38	49.06	6.92	123.82	55.12
10	55.89	46.70	85.25	94.03	97.91	82.24	79.87	267	215	34.84	119.20	7.84	43.64	3.80	123.90	26.46
11	50.71	44.61	85.29	91.25	66.62	54.52	59.56	268	215	34.84	112.70	6.42	42.94	3.16	126.30	31.94
12	48.59	45.14	85.19	88.77	40.18	30.86	44.30	269	214	36.04	105.10	4.56	44.62	3.66	140.10	49.66
13	56.55	45.73	75.93	86.29	114.94	96.89	80.33	266	215	33.08	108.90	10.20	41.86	4.02	114.10	21.92
14	51.01	44.17	75.82	82.41	73.49	61.19	54.91	268	215	33.74	97.00	6.56	42.04	3.50	114.50	28.56
15	48.43	45.62	75.13	78.08	32.93	25.18	36.13	268	215	36.30	86.10	3.58	45.36	4.08	137.86	58.42
16	53.00	43.99	66.73	75.27	95.55	80.75	57.98	269	215	32.72	86.50	7.80	41.12	3.76	104.30	24.42
17	51.94	45.71	66.18	71.89	64.38	55.70	44.62	271	215	33.96	79.00	5.68	43.72	4.74	108.24	33.32
18	48.29	44.88	66.34	69.79	38.51	30.50	34.79	268	215	35.32	74.00	3.84	44.40	4.18	123.08	51.36
19	49.15	40.31	80.31	88.85	95.48	78.99	74.32	269	214	31.78	110.20	7.66	37.10	0.82	114.90	21.96
20	46.67	40.59	81.05	87.02	66.83	54.30	57.22	268	215	32.14	104.70	6.14	39.40	2.74	120.32	30.12
21	44.19	40.73	80.67	84.33	41.11	30.86	43.72	270	214	32.94	97.60	4.44	40.32	2.60	133.26	46.84
22	51.35	40.55	70.42	80.66	113.78	96.82	75.82	267	215	30.70	97.70	8.74	36.28	1.08	106.42	20.20
23	45.88	39.38	71.07	77.28	69.12	57.86	50.91	267	214	31.34	88.10	6.30	38.24	2.40	108.56	27.70
24	43.78	40.63	71.18	74.51	37.45	28.01	37.07	270	214	33.26	80.80	3.76	40.48	2.38	125.74	49.60
25	50.13	40.23	66.80	76.07	103.24	88.68	65.01	267	215	30.40	89.10	8.42	37.62	2.80	102.72	21.34
26	46.76	40.08	65.58	71.96	71.14	59.50	47.84	268	214	31.00	79.60	5.90	38.56	3.10	103.86	28.48
27	43.52	39.97	65.64	69.30	40.90	31.69	36.07	268	214	32.16	73.00	3.82	39.60	2.82	117.22	46.00

Table 2.16: Normal CF3 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	61.11	51.32	85.97	95.36	104.18	88.30	83.11	266	216	37.12	123.40	9.20	47.22	5.32	126.64	26.94
2	55.90	49.59	85.47	91.52	67.77	56.64	59.03	269	216	37.14	114.30	7.40	47.34	5.38	128.94	33.88
3	53.76	50.45	85.69	89.05	37.71	29.73	42.74	269	215	38.84	106.30	4.90	49.68	5.96	146.34	55.26
4	60.59	50.28	75.84	85.65	108.12	92.87	71.84	264	216	36.18	107.70	10.54	46.34	5.30	114.74	23.02
5	56.64	50.40	76.30	82.26	66.22	56.00	50.62	267	215	36.64	96.30	6.36	47.96	6.46	120.28	34.80
6	53.25	50.53	75.90	78.65	30.50	24.33	35.37	267	215	38.84	87.40	3.50	50.04	6.42	144.96	64.56
7	58.79	49.54	71.07	79.70	95.35	82.92	61.15	265	215	35.32	94.80	8.48	45.92	5.60	110.58	26.02
8	56.41	50.17	66.31	72.04	64.35	56.16	43.73	269	216	35.98	79.10	6.02	47.72	6.84	110.94	35.76
9	53.95	50.17	64.49	68.12	40.73	33.91	34.58	269	215	36.86	71.80	4.02	48.98	7.24	122.88	52.72
10	55.54	46.51	85.42	94.14	97.40	81.28	79.61	268	216	34.72	122.20	9.36	43.40	3.78	124.12	25.22
11	50.72	44.68	85.63	91.57	66.44	54.11	59.91	268	215	34.48	113.70	6.74	42.90	3.50	127.52	32.52
12	48.60	45.20	85.17	88.68	39.52	30.50	44.29	270	215	35.84	105.30	4.48	44.68	3.76	141.46	51.00
13	56.40	45.58	76.15	86.49	115.12	97.10	80.65	267	215	33.06	109.30	10.34	41.76	4.00	114.66	22.08
14	51.26	44.56	76.09	82.52	71.86	60.05	54.36	268	215	33.80	96.90	6.44	42.40	3.96	115.48	29.66
15	48.39	45.50	75.79	78.74	33.15	25.88	36.72	269	214	36.02	87.30	3.52	45.22	4.26	137.80	57.00
16	54.82	44.77	70.18	79.98	104.26	90.03	67.26	255	215	32.52	96.10	9.18	41.32	4.20	108.02	22.50
17	51.61	45.09	66.55	72.65	68.80	58.41	46.31	271	215	33.20	80.10	6.04	42.82	4.78	107.66	31.54
18	48.42	44.92	66.67	70.20	39.81	31.38	35.37	270	215	34.94	74.00	3.76	44.26	4.34	122.82	51.02
19	49.44	40.50	80.70	89.28	95.50	79.95	75.07	267	215	31.94	111.80	7.84	37.42	0.80	115.68	21.96
20	46.88	40.76	81.11	87.13	67.44	54.84	57.50	269	215	32.14	105.00	6.06	39.60	2.86	120.52	30.04
21	43.78	40.29	80.68	84.39	41.83	31.20	43.73	270	215	32.96	97.30	4.34	40.10	2.40	132.60	46.36
22	51.57	40.66	70.63	81.00	115.06	97.77	77.08	266	215	30.46	98.40	9.06	36.70	1.76	107.34	20.62
23	46.18	39.60	71.22	77.52	70.58	58.88	51.46	269	215	31.02	88.60	6.26	38.36	2.90	109.04	28.00
24	43.51	40.27	71.35	74.76	38.35	29.02	37.36	270	215	33.08	81.10	3.68	40.22	2.46	125.22	48.68
25	51.94	42.01	68.17	77.40	102.84	89.10	65.25	267	216	31.24	91.40	8.08	39.16	3.44	104.50	21.88
26	46.86	40.15	65.69	72.13	71.94	59.98	47.75	268	214	30.94	79.50	5.94	38.60	3.12	103.94	28.40
27	44.01	40.53	65.28	68.82	39.58	31.25	35.41	268	215	32.34	72.30	3.84	40.10	3.12	118.36	47.58

Table 2.17: Normal CF4 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.58	50.80	85.72	95.09	103.96	87.91	82.88	266	216	36.72	122.50	8.96	46.80	5.22	125.88	26.72
2	55.99	49.71	85.43	91.47	67.39	56.40	58.72	268	216	37.10	114.30	7.30	47.46	5.42	129.24	34.22
3	53.44	50.11	85.62	88.99	37.87	29.89	42.91	270	215	38.54	106.50	4.94	49.30	5.82	146.00	54.76
4	60.68	50.27	75.89	85.79	109.10	93.60	72.95	265	216	35.82	108.10	10.80	46.14	5.38	115.10	23.24
5	56.32	50.12	76.22	82.15	66.13	55.57	50.56	267	215	36.56	96.10	6.34	47.72	6.32	120.12	34.90
6	53.06	50.41	75.96	78.68	30.24	23.67	35.19	267	215	38.86	87.60	3.66	49.96	6.44	144.46	64.02
7	58.88	49.59	71.24	79.98	96.68	83.28	61.86	266	215	35.26	95.50	8.86	45.88	5.72	110.82	25.64
8	56.39	50.16	66.35	72.07	64.21	55.78	43.68	270	215	35.72	79.30	5.76	47.72	7.00	111.42	36.00
9	54.04	50.14	65.11	68.78	41.22	35.02	35.15	269	216	36.90	72.60	4.10	48.96	7.08	122.38	51.48
10	56.02	46.85	85.59	94.34	97.68	82.19	79.96	268	215	35.08	119.70	8.00	43.78	3.70	124.42	26.52
11	50.52	44.42	85.71	91.65	66.83	54.68	60.04	269	215	34.60	114.00	6.60	42.70	3.34	127.10	32.38
12	49.19	45.85	85.27	88.73	38.84	29.94	44.20	269	215	36.24	105.20	4.60	45.26	4.12	142.00	51.46
13	56.29	45.42	76.14	86.50	115.22	97.39	80.64	267	215	33.08	109.30	10.30	41.66	3.76	114.20	21.74
14	52.42	45.51	76.31	82.93	73.87	61.84	55.28	268	215	33.88	97.90	6.56	43.08	4.42	115.78	29.44
15	48.42	45.50	75.83	78.79	33.06	26.14	36.75	269	215	35.88	87.50	3.56	45.22	4.42	137.82	57.44
16	54.52	44.33	70.09	79.65	105.96	91.12	67.81	266	215	32.20	95.30	9.00	40.88	3.98	107.30	22.30
17	51.67	45.29	66.26	72.12	66.21	57.28	45.45	271	216	33.28	79.40	5.78	43.08	4.92	107.98	32.50
18	48.56	45.18	66.22	69.56	37.52	30.22	34.58	269	215	34.96	73.10	3.68	44.64	4.82	123.98	52.78
19	49.12	40.34	80.00	88.46	94.22	78.67	73.01	267	215	31.98	110.20	8.02	37.38	0.72	113.92	20.94
20	46.15	39.99	80.69	86.69	67.13	54.94	57.14	268	214	32.04	104.20	6.12	39.04	2.46	119.56	29.58
21	43.80	40.28	80.38	84.13	42.14	31.40	43.59	270	214	33.04	97.10	4.06	40.02	2.28	131.90	46.08
22	51.17	40.45	69.91	80.02	112.20	96.05	74.42	266	215	30.42	96.70	8.88	36.32	1.42	106.30	20.64
23	45.59	39.31	69.76	75.86	68.45	56.25	49.48	269	215	30.80	86.10	6.44	37.96	2.70	108.08	28.50
24	43.48	40.45	69.53	72.74	35.99	27.12	35.59	269	214	32.96	77.60	3.40	40.32	2.64	125.90	52.04
25	48.18	39.41	63.45	71.65	91.64	78.23	56.29	268	214	29.96	80.40	7.50	37.12	2.78	99.86	23.74
26	46.60	40.09	64.59	70.81	69.27	58.42	46.56	267	216	30.56	77.70	6.04	38.44	3.32	103.46	29.16
27	43.45	40.11	64.14	67.58	38.29	29.79	34.45	267	214	32.24	70.70	3.62	39.82	2.92	117.68	48.22

**Table 2.18: Normal CF5 test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.61	50.92	85.32	94.53	101.19	87.16	81.33	264	216	36.54	121.30	8.72	46.88	5.40	125.38	26.94
2	55.54	49.35	85.16	91.12	66.28	55.38	58.28	267	215	36.94	113.40	7.12	47.12	5.24	128.68	34.08
3	53.78	50.53	85.36	88.68	37.12	29.12	42.27	269	215	38.96	105.50	4.48	49.84	6.12	146.88	56.08
4	60.21	50.29	74.87	84.22	103.02	89.29	68.98	264	216	35.70	104.00	9.90	46.22	5.58	114.12	24.30
5	56.28	50.26	75.41	81.19	64.18	53.99	49.08	267	215	37.20	94.20	6.10	48.12	6.04	119.74	35.42
6	53.13	50.45	75.62	78.37	30.51	23.94	35.03	266	215	39.12	86.80	3.66	50.08	6.14	145.02	64.76
7	57.53	49.20	68.41	76.19	86.31	74.88	54.63	266	216	35.10	88.20	7.86	45.92	5.80	108.68	27.88
8	55.95	50.10	65.39	70.75	60.51	52.34	41.71	271	215	36.22	81.92	5.52	47.80	6.66	111.30	37.70
9	53.35	49.93	62.97	66.26	36.68	30.61	32.79	268	215	37.44	68.60	3.56	49.06	6.70	124.66	56.64
10	55.54	46.47	85.21	93.90	96.93	81.26	79.49	268	215	34.62	118.80	7.72	43.28	3.68	123.98	26.66
11	50.54	44.47	85.41	91.34	66.34	54.32	59.66	269	215	34.46	113.10	6.48	42.66	3.34	127.10	32.58
12	49.15	45.80	85.10	88.58	39.16	30.03	43.85	270	215	36.18	104.80	4.58	45.14	4.06	141.82	51.50
13	56.39	45.62	76.03	86.37	114.64	96.57	80.47	266	215	32.86	109.60	10.58	41.72	4.16	114.52	21.96
14	50.77	43.97	75.97	82.56	73.40	60.80	54.93	267	215	33.52	96.80	6.40	41.94	3.64	114.82	29.06
15	48.18	45.33	75.43	78.42	33.37	25.53	36.49	268	215	36.30	86.80	3.58	45.10	3.98	137.22	57.18
16	54.48	44.77	69.55	78.67	101.54	86.83	64.41	267	215	32.44	93.50	8.68	41.32	4.14	107.02	23.14
17	51.36	44.88	66.35	72.41	68.25	57.99	45.93	270	215	33.12	79.50	5.76	42.66	4.84	107.50	32.20
18	48.59	45.22	66.36	69.76	37.86	30.15	34.60	268	215	34.84	73.70	3.74	44.60	4.76	124.52	52.68
19	49.18	40.40	80.21	88.68	94.34	78.79	73.35	267	215	31.58	110.80	7.86	37.26	1.08	115.68	22.58
20	46.82	40.79	81.01	86.94	66.28	54.02	56.89	268	215	32.00	104.20	6.00	39.56	2.94	120.74	30.76
21	43.71	40.23	80.57	84.27	41.47	31.03	43.55	269	214	32.74	97.60	4.20	40.02	2.52	132.72	46.66
22	51.39	40.60	70.41	80.68	113.46	96.69	75.82	265	215	30.40	98.00	8.86	36.80	2.04	106.94	20.56
23	46.20	39.75	71.08	77.25	68.94	57.62	51.01	268	215	30.72	88.30	6.24	38.32	3.10	109.24	28.32
24	43.77	40.58	71.19	74.54	37.53	28.43	37.11	270	214	32.78	80.60	3.50	40.22	2.78	126.12	50.00
25	50.43	40.55	67.01	76.25	102.86	88.55	65.10	267	215	30.16	89.40	8.42	37.74	3.08	103.22	21.58
26	46.73	39.91	66.00	72.53	72.80	60.96	48.69	268	215	31.14	80.30	6.06	38.44	2.88	103.86	27.86
27	43.99	40.42	66.31	70.03	41.42	31.87	36.52	267	214	32.48	74.40	4.08	40.02	2.86	117.80	45.72

**Table 2.19: Normal CF6 test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.60	50.82	85.47	94.86	103.96	87.82	82.28	266	216	36.76	122.00	9.00	46.88	5.14	125.42	26.40
2	55.64	49.42	85.15	91.12	66.61	55.85	58.12	268	215	37.14	113.40	7.30	47.24	5.12	128.48	33.92
3	53.26	49.96	85.35	88.70	37.49	29.53	42.58	269	215	38.82	105.30	4.62	49.26	5.58	145.86	55.40
4	60.33	50.41	74.97	84.33	103.46	89.17	68.93	265	216	35.86	104.60	9.98	46.44	5.64	114.12	23.94
5	56.68	50.66	75.65	81.34	62.87	53.96	48.99	265	215	37.34	94.80	6.30	48.38	6.06	120.02	35.60
6	52.77	50.11	75.55	78.32	30.80	23.75	35.04	266	214	39.30	86.90	3.36	49.80	5.64	143.68	63.46
7	57.45	49.05	68.51	76.36	87.21	75.36	54.56	267	215	35.54	88.30	7.88	45.88	5.36	108.32	27.56
8	56.05	50.22	65.37	70.67	59.56	52.22	41.51	270	215	35.82	76.90	5.64	47.96	7.12	112.00	38.24
9	53.31	49.94	62.93	66.20	36.50	30.28	32.66	268	216	37.58	68.50	3.56	49.08	6.64	124.68	56.62
10	55.36	46.32	85.02	93.77	97.45	80.84	79.31	267	215	34.54	118.20	7.46	43.20	3.56	123.56	26.56
11	50.60	44.71	85.03	90.80	64.38	52.80	58.24	268	215	34.72	112.30	6.42	43.04	3.22	126.92	32.80
12	48.38	45.01	84.78	88.32	39.61	30.22	43.93	269	215	35.86	104.40	4.28	44.50	3.66	140.56	50.72
13	55.58	45.32	74.77	84.53	108.52	91.87	73.51	267	215	32.98	104.50	9.60	41.80	4.16	112.08	21.96
14	50.79	44.53	74.38	80.36	66.83	56.18	50.90	268	215	33.86	93.40	6.20	42.66	3.96	115.10	31.28
15	48.15	45.33	74.98	77.91	32.79	25.23	36.06	269	214	35.94	86.30	3.54	45.14	4.30	137.72	57.82
16	53.93	44.45	67.84	76.75	99.32	85.03	61.59	267	215	32.62	89.90	8.24	41.32	4.04	105.54	23.80
17	51.68	45.71	65.45	71.06	63.14	53.54	43.39	271	215	34.04	77.50	5.52	43.80	4.96	108.16	34.18
18	48.49	45.25	65.38	68.59	36.05	28.87	33.61	270	214	35.00	71.90	3.52	44.82	4.88	124.80	54.36
19	49.21	40.58	79.37	87.71	92.70	77.37	70.78	267	215	31.70	108.60	7.84	37.72	1.46	114.86	22.70
20	46.55	40.59	80.30	86.26	66.54	53.31	55.94	268	215	32.36	102.96	6.02	39.56	2.58	119.84	30.54
21	44.05	40.61	80.02	83.71	41.53	30.73	43.04	270	215	33.00	96.30	4.28	40.32	2.48	132.60	47.16
22	50.66	40.38	68.83	78.57	108.32	91.96	69.85	267	215	30.66	93.70	8.60	36.62	1.50	104.70	20.78
23	45.47	39.34	69.06	75.02	66.59	54.75	48.17	269	215	30.96	84.60	6.14	38.24	2.68	107.88	29.16
24	43.10	40.08	69.19	72.43	36.37	27.03	35.54	269	215	32.98	76.90	3.14	40.08	2.40	125.08	51.22
25	49.21	40.37	64.19	72.46	92.41	79.09	57.40	268	215	30.64	82.50	7.58	37.88	2.78	100.70	23.42
26	46.78	40.10	65.53	71.94	71.44	59.67	47.83	267	215	31.28	79.80	5.92	38.66	2.86	103.74	28.24
27	43.79	40.27	65.82	69.45	40.28	31.42	35.91	267	214	32.14	73.60	4.06	39.82	3.16	117.78	46.22

Table 2.20: Normal NC test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.82	51.09	85.92	95.28	103.32	87.19	82.33	265	215	36.68	122.60	8.88	47.04	5.32	126.08	27.08
2	55.91	49.64	85.43	91.49	67.49	55.97	58.61	268	214	37.08	114.20	7.38	47.34	5.36	129.12	33.98
3	53.51	50.19	85.58	88.97	37.83	29.58	42.63	268	214	38.74	105.80	4.72	49.46	5.90	146.34	55.74
4	60.80	50.49	75.88	85.67	107.80	92.36	71.78	264	215	35.82	107.10	10.70	46.34	5.50	115.10	23.52
5	56.58	50.39	76.12	82.03	65.54	55.37	49.87	266	215	37.16	95.80	6.36	48.10	6.08	119.76	34.56
6	52.97	50.23	75.86	78.68	31.29	24.45	35.41	266	215	39.10	87.80	3.66	49.76	5.76	143.82	63.24
7	58.78	49.54	70.82	79.44	95.12	82.55	60.75	265	214	35.46	94.50	8.60	45.92	5.52	110.30	25.66
8	56.24	50.10	66.20	71.80	63.22	54.89	43.28	271	215	36.54	78.60	5.70	47.74	6.32	110.62	35.82
9	53.62	49.92	63.63	67.15	39.26	33.14	33.82	268	215	36.94	70.30	3.84	48.82	6.94	122.52	53.34
10	55.65	46.49	85.17	93.98	98.38	82.19	79.79	268	215	34.72	119.40	8.10	43.28	3.70	123.76	26.12
11	50.91	44.76	85.35	91.34	67.22	55.00	59.74	269	215	34.52	113.60	6.72	42.94	3.56	126.88	32.46
12	48.86	45.38	84.98	88.54	40.08	31.16	44.45	270	214	36.22	104.80	4.62	44.90	3.94	140.76	50.38
13	56.84	46.15	75.85	86.01	112.90	95.83	78.30	267	215	33.36	108.50	10.38	42.26	4.08	113.78	21.62
14	51.39	44.50	75.80	82.36	73.07	61.48	54.64	267	214	33.72	96.90	6.56	42.40	4.00	114.82	29.08
15	48.23	45.44	74.82	77.71	32.41	24.91	35.84	268	214	35.92	86.10	3.60	45.18	4.22	138.34	58.72
16	53.25	43.93	67.17	75.94	97.65	83.45	60.11	267	215	32.54	88.00	7.96	41.00	3.74	104.74	23.90
17	51.36	45.19	65.45	71.18	64.66	55.09	43.81	271	214	33.66	77.70	5.70	43.20	4.70	107.54	33.30
18	48.49	45.25	65.25	68.44	35.61	28.82	33.42	268	214	35.06	71.70	3.66	44.80	4.78	125.02	54.50
19	49.25	40.79	78.88	87.01	91.01	75.58	68.21	269	214	32.10	107.10	7.64	37.92	1.18	113.96	22.66
20	46.21	40.16	80.25	86.18	66.42	53.83	55.88	269	214	31.82	103.04	6.08	39.14	2.72	119.74	30.42
21	43.84	40.40	79.93	83.63	41.58	30.71	42.80	270	214	32.88	96.40	4.34	40.08	2.44	132.42	46.84
22	50.52	40.41	68.52	78.03	105.54	90.62	67.23	266	215	30.58	92.50	8.52	37.36	2.22	104.30	21.10
23	45.47	39.07	70.37	76.56	69.12	57.48	49.97	268	215	31.16	86.60	6.00	37.88	2.24	108.20	28.34
24	43.43	40.28	69.86	73.14	36.63	28.02	36.12	269	214	32.54	78.42	3.38	40.10	2.88	125.52	50.88
25	48.71	39.96	63.59	71.74	90.86	78.09	55.71	267	214	30.22	80.50	7.22	37.64	3.04	100.30	24.10
26	46.30	39.95	64.24	70.30	67.64	56.60	45.16	268	214	31.08	76.50	5.70	38.62	2.90	103.38	29.90
27	43.60	40.37	63.68	67.02	37.45	28.84	33.98	269	214	32.24	70.00	3.70	40.12	3.20	118.86	49.52

**Table 2.21: Normal DPV test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	59.72	50.47	85.33	96.44	105.26	83.31	78.35	227	216	37.98	126.80	10.42	47.46	4.56	125.44	24.44
2	56.40	50.63	85.41	92.38	66.46	51.87	56.82	229	216	38.40	114.78	7.44	48.90	5.70	132.06	36.76
3	53.14	50.30	85.32	88.97	34.78	25.56	40.59	229	216	39.38	105.20	4.90	50.04	5.82	152.34	61.78
4	60.69	50.00	75.85	90.02	121.04	96.07	78.61	205	216	36.64	115.62	12.52	46.38	4.88	118.18	22.42
5	56.10	50.41	75.79	82.47	64.09	51.17	48.57	230	216	37.74	96.30	6.96	48.74	6.04	122.94	37.22
6	52.42	49.98	75.40	78.56	30.37	21.89	34.49	231	215	39.20	86.70	3.58	49.98	5.96	148.46	68.44
7	58.76	49.93	70.59	82.07	98.30	79.47	61.04	206	216	36.90	99.00	10.18	46.98	5.26	113.10	26.30
8	55.67	50.00	64.88	72.11	62.00	50.98	42.10	206	216	36.38	79.50	7.42	48.20	6.88	114.00	38.56
9	53.31	49.95	62.98	66.89	37.44	30.07	32.80	230	215	37.72	69.60	4.28	49.32	6.70	126.56	57.58
10	54.34	45.78	85.00	95.26	97.45	76.97	76.37	228	216	35.14	123.60	9.54	43.48	3.22	124.32	24.58
11	49.73	44.17	85.51	92.49	66.55	49.77	58.67	229	215	35.08	114.86	7.38	42.96	2.94	129.92	34.54
12	48.05	45.02	85.34	89.40	38.94	27.10	43.39	230	215	36.54	106.00	5.26	44.80	3.36	144.94	54.08
13	55.37	45.35	74.86	87.79	114.18	90.12	75.58	212	216	34.12	110.50	10.96	42.40	3.38	114.98	21.94
14	50.04	44.66	75.12	81.61	62.39	48.30	48.64	231	216	34.76	94.80	6.62	43.40	3.74	120.08	35.42
15	47.48	44.99	75.13	78.51	32.49	22.30	35.35	231	215	36.58	86.80	3.68	45.02	3.62	141.80	61.80
16	55.58	45.28	70.42	83.87	114.96	92.62	72.61	205	216	33.50	103.80	11.62	42.08	3.80	111.48	21.90
17	49.20	43.97	59.88	66.41	58.26	46.96	38.99	214	215	32.90	70.80	6.70	42.58	4.88	107.14	37.52
18	47.84	45.33	61.35	64.52	30.69	22.55	30.35	233	215	35.72	65.76	3.10	45.36	4.72	130.66	64.72
19	48.21	40.53	76.91	86.01	86.99	68.97	62.84	229	216	32.50	104.50	9.56	39.24	2.00	114.28	24.14
20	45.55	40.01	80.01	86.90	65.82	49.62	54.32	229	215	32.78	103.22	6.64	39.40	1.82	121.92	32.40
21	43.38	40.37	80.15	84.28	39.66	26.97	41.26	230	215	33.70	95.90	3.32	40.34	1.96	135.78	50.70
22	51.00	40.41	71.15	84.20	119.00	95.03	76.95	219	215	31.48	104.20	12.20	38.08	2.04	110.12	20.24
23	45.31	39.48	70.32	77.33	67.21	52.13	48.66	230	215	32.08	87.30	6.86	38.64	1.92	110.98	30.68
24	43.20	40.36	70.49	74.33	37.12	25.41	35.71	232	215	33.58	79.20	2.64	40.44	2.00	127.78	52.72
25	51.41	40.62	67.95	82.08	121.14	96.88	76.12	206	216	31.06	100.80	12.80	38.04	2.52	108.48	20.46
26	45.80	40.14	63.05	69.86	64.85	50.61	43.26	229	214	31.16	75.90	6.74	39.06	3.32	105.70	32.84
27	43.29	40.42	63.01	66.68	35.50	25.74	32.95	232	215	32.48	69.40	4.10	40.30	3.16	123.04	54.42

## 2.1 Reduced Condenser Water Flow

An electronic valve regulated the water flow rate in the condenser by changing the head pressure across the water pump. The base water flow rate was 270 gpm and each fault level reduced the water flow rate by 10% as shown in Table 2.22. The accuracy of the fault level depends on the condenser water flow rate measurement, which has an uncertainty of  $\pm 2.8$  gpm.

**Table 2.22: Fault levels for reduced condenser water flow**

<b>Case</b>	<b>Desired Condition</b>	<b>Actual Flow Range</b>
<b>Normal Operation</b>	270 gpm	264-270 gpm
<b>Fault Level 1</b>	10% reduction in flow (243 gpm)	234-250 gpm
<b>Fault Level 2</b>	20% reduction in flow (216 gpm)	209-219 gpm
<b>Fault Level 3</b>	30% reduction in flow (189 gpm)	187-190 gpm
<b>Fault Level 4</b>	40% reduction in flow (162 gpm)	159-166 gpm

The following tables also include an extra test at the second fault level, FWC20 alt, which did not meet the operating conditions as well as FWC20.

**Table 2.23: FWC10 test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.84	50.90	85.85	96.74	106.34	89.48	84.95	234	216	37.82	129.30	10.76	47.30	4.60	126.64	24.34
2	56.71	50.73	85.45	92.02	64.79	53.69	57.65	237	216	38.40	114.78	7.10	48.78	5.60	130.74	35.42
3	53.42	50.37	85.36	88.95	35.46	27.47	41.64	237	215	39.52	105.40	4.76	49.96	5.66	148.82	58.04
4	60.83	49.82	75.93	87.43	116.24	99.24	77.51	242	216	36.66	110.80	10.36	46.02	4.52	115.18	21.88
5	56.28	49.98	76.47	83.26	68.26	56.67	51.74	241	216	37.82	98.50	6.80	47.86	5.12	120.04	33.28
6	52.61	50.00	75.52	78.54	30.47	23.39	35.14	242	215	39.48	86.90	3.62	49.80	5.56	145.22	65.18
7	58.78	49.38	71.18	80.84	98.19	84.45	62.95	244	216	36.14	97.40	9.06	46.10	5.10	110.78	24.68
8	56.14	49.96	65.99	72.24	63.93	55.43	43.91	246	215	36.74	79.90	6.16	47.80	6.20	111.14	35.52
9	53.74	50.00	64.28	68.20	39.66	33.66	34.89	243	215	37.56	72.20	4.70	49.06	6.58	123.28	52.54
10	54.07	45.02	85.33	95.17	97.73	81.69	80.39	238	217	35.04	124.50	9.24	42.90	2.82	123.88	23.92
11	51.41	45.65	85.68	92.10	63.84	51.62	58.85	239	215	35.38	114.40	6.72	44.14	3.80	129.36	34.16
12	48.49	45.21	85.39	89.30	38.96	29.37	44.26	239	215	36.86	106.40	4.92	44.80	3.22	142.44	51.56
13	56.28	45.13	75.87	88.05	119.52	100.46	84.59	236	216	33.84	112.30	10.48	41.92	3.28	115.52	21.56
14	50.53	44.49	75.86	82.36	65.45	54.21	51.71	242	216	34.38	96.60	6.52	42.90	3.62	118.10	32.44
15	47.73	45.05	75.40	78.59	32.20	24.08	36.16	243	215	36.34	86.90	3.60	44.94	3.76	139.12	59.08
16	56.03	45.11	71.31	82.72	115.62	98.41	75.39	243	216	33.20	101.90	10.22	41.54	3.76	109.92	21.10
17	51.18	44.06	65.67	73.10	75.45	63.90	49.23	244	216	33.48	82.20	6.96	42.02	3.70	105.74	28.68
18	48.53	45.21	66.07	69.71	37.00	29.79	34.81	244	216	35.70	73.90	4.12	44.80	4.12	124.32	52.42
19	49.76	40.39	80.66	90.77	100.79	84.13	78.91	239	216	32.24	115.52	10.10	37.78	0.84	117.50	21.88
20	46.19	40.29	80.47	87.04	65.65	52.89	56.46	240	215	32.74	105.10	7.12	39.42	2.02	121.44	31.10
21	43.38	40.01	80.44	84.51	40.72	30.20	42.96	240	215	33.16	96.90	3.74	39.90	1.96	133.02	47.24
22	51.87	40.65	70.53	82.26	118.64	100.59	80.49	243	215	30.84	101.80	10.86	37.78	2.38	108.84	20.38
23	45.62	39.22	70.72	77.58	69.07	57.24	50.92	242	215	31.94	88.60	7.48	38.16	1.66	109.16	27.94
24	43.25	40.15	70.88	74.55	37.12	27.68	36.86	242	215	33.26	80.30	3.16	40.06	2.12	125.32	49.46
25	49.31	40.09	65.22	74.70	96.74	82.82	60.46	245	216	31.20	86.90	9.76	38.00	2.20	102.22	22.16
26	46.84	40.30	64.64	71.35	69.94	58.65	47.26	250	215	31.04	79.00	6.70	38.78	3.06	104.06	29.00
27	43.13	39.90	64.13	67.84	37.60	28.99	34.57	243	215	32.18	71.70	4.00	39.68	2.82	119.08	49.08

Table 2.24: FWC20 alt test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.62	51.13	85.68	97.22	101.94	85.40	82.94	212	216	37.62	130.10	11.72	47.62	5.06	128.50	25.82
2	56.33	50.69	85.36	92.29	61.98	50.71	56.51	215	216	38.46	114.86	7.54	48.92	5.60	132.72	37.54
3	53.47	50.73	85.29	88.88	32.34	24.65	40.33	216	216	39.72	105.50	4.94	50.34	5.88	153.96	63.06
4	60.71	50.09	75.61	88.50	112.78	95.37	76.76	210	215	36.36	113.20	11.78	46.30	5.02	117.18	22.58
5	56.04	50.37	75.44	82.14	60.74	50.99	48.53	217	216	37.78	96.20	6.96	48.50	5.86	122.76	37.24
6	52.71	50.28	75.51	78.64	28.36	21.85	34.45	217	216	39.26	87.00	4.06	50.18	6.12	149.48	69.26
7	58.61	49.84	70.47	81.00	92.19	78.81	60.04	210	216	37.04	97.50	9.54	46.80	4.90	112.04	26.12
8	55.88	49.88	65.66	72.74	62.15	53.93	43.54	211	216	36.70	80.70	7.22	47.80	6.22	112.68	36.58
9	53.62	50.14	64.03	68.11	37.08	31.34	33.74	218	216	37.78	71.70	4.56	49.40	6.76	125.96	55.40
10	53.62	45.37	84.74	94.72	89.64	74.14	74.26	215	216	34.76	121.10	8.76	43.08	3.30	124.68	26.16
11	50.67	45.29	85.52	92.25	60.35	48.20	57.22	216	215	35.40	114.60	7.14	43.92	3.42	131.58	36.52
12	48.48	45.51	85.25	89.15	35.10	26.59	42.73	216	215	36.02	105.90	5.00	45.18	4.20	147.84	56.86
13	56.21	45.79	75.51	88.11	111.70	94.00	79.87	213	216	33.72	112.50	11.26	42.30	3.66	116.10	21.94
14	49.89	44.31	75.70	82.47	61.47	50.09	50.38	218	215	34.24	96.30	6.94	42.74	3.60	119.70	34.28
15	47.88	45.25	75.43	78.81	30.66	23.58	35.99	218	215	35.94	87.50	3.96	45.18	4.38	141.82	61.48
16	56.01	45.40	71.11	83.94	112.38	95.21	74.78	210	215	33.42	104.40	11.34	41.94	3.74	111.48	21.46
17	50.84	43.95	65.59	73.76	73.29	61.99	48.90	215	216	33.46	83.40	7.90	41.98	3.72	106.98	29.26
18	48.10	45.01	66.05	69.89	34.95	27.78	34.13	219	215	35.22	74.00	4.50	44.64	4.40	126.84	54.78
19	49.14	40.57	80.08	90.41	92.84	76.64	72.80	216	215	32.38	114.30	10.16	38.70	1.70	117.90	22.84
20	45.79	40.38	80.40	87.23	61.88	48.63	54.83	217	215	32.62	104.90	7.44	39.56	2.32	123.88	33.72
21	43.39	40.42	80.23	84.34	37.11	26.54	41.33	217	215	33.28	96.90	4.66	40.34	2.26	137.62	51.64
22	51.39	40.63	70.24	83.30	113.92	96.47	77.55	209	215	31.32	103.50	11.86	37.94	2.02	109.74	20.38
23	45.69	39.76	70.61	77.76	64.99	53.10	49.66	218	215	31.34	89.00	7.34	38.58	2.66	112.08	30.80
24	43.51	40.69	70.64	74.37	33.91	25.20	35.98	218	215	32.96	80.90	4.34	40.40	2.66	130.84	54.72
25	49.50	40.37	65.33	76.30	96.26	81.81	61.90	211	215	30.72	89.90	10.34	38.12	2.92	104.42	22.86
26	46.58	40.30	64.79	72.29	67.46	56.31	47.02	216	215	30.96	80.60	7.40	38.78	3.46	106.06	29.94
27	42.99	39.95	64.67	68.70	36.64	27.17	34.29	218	214	32.62	72.30	4.26	39.86	2.58	121.46	51.06

Table 2.25: FWC20 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	59.88	50.54	85.57	97.21	101.46	84.05	82.41	209	216	37.64	129.50	11.36	47.10	4.54	128.08	25.76
2	56.18	50.55	85.36	92.37	61.43	50.68	56.53	210	216	38.04	115.16	7.86	48.64	5.68	133.26	37.68
3	52.75	49.96	85.35	89.10	32.98	24.99	40.40	211	215	39.28	105.70	4.90	49.68	5.58	152.58	62.00
4	60.64	49.76	75.68	88.43	115.14	97.44	78.35	217	215	35.94	113.00	11.72	45.84	4.98	117.00	22.66
5	56.18	50.29	75.47	82.35	62.67	52.84	49.48	219	215	37.54	96.80	7.26	48.30	5.78	121.94	36.14
6	52.67	50.27	75.40	78.51	28.14	21.45	34.24	217	215	39.56	86.70	3.84	50.22	5.80	149.92	69.76
7	58.67	49.78	70.50	81.14	93.23	80.17	60.86	210	217	36.68	97.70	9.78	46.68	5.12	112.16	25.86
8	55.95	49.92	65.66	72.69	61.85	54.11	43.57	211	215	36.18	80.80	7.34	47.78	6.66	112.98	36.66
9	53.50	50.01	64.12	68.31	37.69	31.28	34.08	216	215	37.86	72.20	4.86	49.22	6.46	125.62	54.86
10	55.05	46.45	85.40	95.98	94.13	77.38	78.85	214	216	35.32	126.00	10.08	43.82	3.58	126.48	25.62
11	50.84	45.47	85.55	92.31	60.49	48.15	57.15	215	215	35.44	114.60	7.20	44.14	3.62	131.88	36.54
12	48.23	45.21	85.33	89.35	35.94	27.07	43.00	215	215	36.06	106.20	5.10	44.84	3.88	146.74	55.76
13	55.62	45.07	75.49	88.29	113.26	94.65	80.88	212	215	33.54	112.50	11.02	41.90	3.44	116.16	21.90
14	49.69	44.33	75.49	82.07	59.40	48.24	49.24	217	216	34.42	95.80	6.98	42.88	3.58	120.32	35.12
15	47.55	44.98	75.40	78.78	30.57	22.96	35.85	217	215	35.90	87.30	4.08	44.88	3.92	141.46	61.14
16	55.41	44.80	70.64	83.11	112.60	95.33	74.38	217	216	32.82	102.88	11.04	41.36	3.76	110.66	21.58
17	50.96	44.13	65.37	73.24	71.44	61.32	48.38	218	216	32.98	82.50	7.86	42.02	4.38	107.14	29.82
18	48.39	45.29	65.57	69.31	34.14	27.82	33.70	219	215	35.18	73.30	4.42	44.90	4.64	127.62	56.28
19	49.59	40.66	80.45	91.17	96.88	79.94	77.14	217	215	32.12	115.34	9.68	38.82	2.08	119.32	23.78
20	45.47	39.99	80.24	87.10	61.95	49.01	54.94	217	214	32.52	104.60	7.36	39.22	2.00	123.38	33.30
21	43.12	40.04	80.19	84.38	38.07	27.45	41.91	218	214	33.02	97.70	4.50	40.02	2.32	136.44	50.26
22	51.73	40.72	70.25	83.21	117.04	98.76	80.55	217	215	30.72	103.40	11.56	37.82	2.54	110.46	20.92
23	45.47	39.52	70.27	77.37	64.53	53.33	49.56	218	215	31.28	88.40	7.28	38.42	2.74	111.76	30.76
24	43.16	40.33	70.34	74.15	34.71	25.42	36.06	219	215	32.94	80.30	4.48	40.16	2.56	129.40	53.42
25	48.51	39.37	63.63	74.23	96.48	81.92	60.25	219	215	30.02	86.30	10.18	37.16	2.76	102.34	22.56
26	45.62	40.06	61.56	68.16	59.84	49.73	41.87	217	215	31.36	73.60	6.90	38.90	3.02	104.62	33.04
27	42.55	39.97	61.22	64.62	31.01	23.04	31.01	219	214	32.74	66.12	3.38	39.90	2.52	123.08	56.96

Table 2.26: FWC30 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	59.75	50.51	85.37	98.20	101.32	83.09	80.75	190	216	38.64	131.20	11.60	47.64	4.18	127.52	24.42
2	56.05	50.77	85.22	92.68	58.75	47.65	55.30	189	216	39.32	115.72	8.26	49.30	5.14	134.52	38.68
3	52.56	50.07	85.20	89.03	30.15	22.40	39.37	189	215	39.98	105.30	5.20	50.02	5.20	157.16	66.86
4	60.87	50.20	75.71	90.22	113.80	96.15	78.57	188	216	37.44	116.80	12.46	46.68	4.36	118.26	21.90
5	55.51	49.92	75.35	83.03	60.87	50.24	48.86	190	215	38.46	97.70	7.70	48.34	5.06	123.22	36.98
6	52.69	50.57	75.02	78.29	25.98	19.06	33.27	191	216	40.12	86.20	3.90	50.64	5.76	154.92	75.36
7	58.73	49.90	70.57	82.46	93.79	79.53	61.73	189	216	37.20	100.10	10.84	46.92	4.70	113.62	25.82
8	55.52	49.98	64.71	72.04	57.97	49.88	41.85	190	216	37.08	79.90	7.68	48.30	6.32	114.38	38.74
9	53.23	50.29	62.33	66.35	31.92	26.40	31.79	191	216	39.16	68.90	4.64	50.04	6.12	130.82	62.44
10	54.03	45.54	85.27	97.22	93.78	76.37	79.32	188	216	36.02	128.32	10.82	43.80	2.96	127.58	25.52
11	50.72	45.89	85.16	92.19	55.27	43.32	54.51	189	216	36.68	114.10	7.60	44.88	3.34	134.22	39.20
12	48.01	45.48	85.11	89.19	32.17	22.84	40.86	190	216	37.40	106.10	5.34	45.42	3.06	151.78	61.02
13	55.66	45.22	75.54	89.97	112.50	93.95	81.08	187	216	34.58	116.30	12.54	42.62	3.14	117.64	21.60
14	49.46	44.07	75.83	83.48	60.77	48.37	50.32	191	216	34.86	98.40	7.82	42.88	2.92	121.26	34.84
15	47.50	45.25	75.14	78.73	28.48	20.12	34.92	191	215	37.34	87.30	4.38	45.30	3.10	146.78	66.38
16	55.65	45.22	70.77	84.89	111.36	93.91	74.38	189	216	34.00	106.40	12.18	42.28	3.34	112.58	21.36
17	50.75	44.19	65.39	74.28	70.88	59.06	48.30	191	216	34.38	84.50	8.64	42.48	3.24	108.44	29.92
18	47.90	45.07	65.63	69.81	33.25	25.39	33.47	191	215	36.10	74.20	4.68	44.86	3.88	129.48	57.66
19	49.34	40.50	80.83	93.12	96.48	79.50	78.69	188	216	33.00	120.40	12.08	38.42	0.82	119.42	21.40
20	45.35	39.99	80.43	88.14	60.62	48.12	54.19	189	215	33.24	105.40	6.76	39.24	1.18	123.76	33.12
21	42.68	39.97	80.15	84.63	35.31	24.35	40.04	189	215	33.72	96.00	2.38	40.08	1.58	138.86	53.72
22	50.53	40.30	70.63	84.59	109.26	91.88	74.92	188	216	31.86	105.60	13.40	38.04	1.54	110.78	20.08
23	45.19	39.06	71.42	79.97	67.84	55.09	52.27	190	215	32.34	91.20	6.90	37.76	0.82	107.86	25.42
24	42.70	40.05	70.71	74.85	32.86	23.70	35.07	190	215	33.88	79.60	1.10	40.08	1.24	130.22	54.84
25	50.87	40.41	67.00	81.06	110.88	93.90	72.06	189	215	31.74	99.70	13.58	38.16	1.84	107.10	19.74
26	45.44	39.93	62.13	69.73	59.73	49.49	42.91	189	215	31.60	76.80	7.96	39.06	2.90	106.74	33.20
27	42.52	39.94	62.34	66.38	32.05	23.25	31.87	190	216	33.32	67.30	2.16	40.08	1.84	123.22	56.08

Table 2.27: FWC40 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	59.71	51.13	85.35	99.74	95.28	77.31	80.81	159	216	38.50	134.10	13.26	48.24	4.96	133.02	28.44
2	55.45	50.76	85.08	92.97	52.88	42.10	53.04	161	215	38.92	116.20	9.00	49.56	5.88	139.64	43.54
3	52.29	50.09	85.18	89.28	27.39	19.71	38.15	160	216	40.04	105.90	5.72	50.18	5.40	164.14	73.16
4	60.69	50.17	75.77	92.27	112.58	94.58	80.84	164	216	37.18	121.70	14.46	46.72	4.64	121.88	23.20
5	55.46	50.08	75.89	84.55	58.60	48.46	49.35	163	216	37.74	100.90	9.08	48.42	5.82	126.98	38.98
6	52.57	50.60	75.16	78.72	24.13	17.71	32.94	163	216	39.94	87.10	4.60	50.80	6.12	160.68	80.26
7	58.86	50.15	70.73	84.20	92.11	78.39	63.03	164	216	37.34	103.90	12.46	47.20	4.98	115.82	26.12
8	55.74	50.12	65.32	73.80	58.13	50.51	42.84	164	216	37.28	82.90	8.90	48.42	6.30	116.22	38.54
9	52.84	50.00	62.54	67.19	31.49	25.42	31.82	163	215	38.74	70.40	5.30	49.58	6.06	132.36	62.96
10	54.19	46.45	85.26	98.12	87.09	69.60	76.81	162	216	36.22	130.70	12.16	44.40	3.28	131.44	28.50
11	50.45	45.91	85.26	92.94	52.37	40.82	53.82	164	216	36.14	115.80	8.72	44.98	3.86	138.10	42.28
12	47.61	45.25	85.15	89.53	29.87	21.10	39.88	164	215	36.98	106.40	5.86	45.38	3.50	157.48	66.36
13	55.64	45.77	75.40	91.57	108.44	88.46	81.29	161	215	34.44	119.70	14.02	42.88	3.60	121.38	23.60
14	49.55	44.74	75.54	83.59	54.46	43.05	48.00	162	215	35.26	98.80	8.48	43.72	3.32	125.94	38.92
15	47.46	45.33	75.22	79.15	26.58	19.09	34.30	162	215	37.06	88.10	4.72	45.60	3.68	151.38	70.64
16	55.83	45.53	70.80	86.97	110.64	92.52	76.75	164	215	33.92	111.20	13.86	42.46	3.68	115.52	22.20
17	50.91	44.43	65.40	75.32	68.75	57.98	48.53	166	215	33.96	86.60	9.98	42.62	3.78	110.86	31.00
18	47.86	45.17	65.70	70.27	31.23	24.12	32.88	164	216	35.80	75.20	4.98	45.18	4.38	133.62	61.30
19	49.00	40.84	80.59	93.88	90.46	73.26	75.44	163	215	33.00	121.90	12.86	39.36	1.68	124.32	25.28
20	45.12	40.37	80.31	88.44	55.36	42.47	52.14	164	215	33.44	106.70	7.78	39.88	1.62	128.16	36.88
21	42.82	40.35	80.17	84.99	32.99	22.13	39.16	164	215	33.98	96.50	3.12	40.50	1.62	143.72	58.14
22	50.40	40.37	70.69	86.82	107.98	89.81	77.63	161	215	31.78	110.60	14.84	38.26	1.90	114.66	21.50
23	45.06	39.37	71.18	80.59	63.71	50.83	50.67	162	215	32.14	94.00	9.00	38.58	1.60	115.38	31.34
24	42.57	40.21	70.77	75.33	30.84	21.10	34.31	163	215	33.92	80.00	1.72	40.36	1.66	134.94	59.06
25	50.90	40.56	66.91	83.06	109.96	92.68	74.79	163	215	31.30	104.00	14.68	38.32	2.60	110.70	20.92
26	45.57	40.09	62.26	71.16	59.40	48.93	43.72	160	214	31.46	79.30	9.20	39.08	3.06	109.20	34.00
27	42.40	40.08	62.41	66.65	28.82	20.75	31.15	163	215	32.82	69.20	4.86	40.16	2.70	130.10	61.64

## 2.2 Reduced Evaporator Water Flow

An electronic valve regulated the water flow rate in the evaporator by changing the head pressure across the water pump. The base water flow rate was 216 gpm and each fault level reduced the water flow rate by about 10% as shown in Table 2.28. The accuracy of the fault level depends on the evaporator water flow rate measurement, which has an uncertainty of  $\pm 2.2$  gpm.

**Table 2.28: Fault levels for reduced evaporator water flow**

<b>Case</b>	<b>Desired Condition</b>	<b>Actual Flow Range</b>
<b>Normal Operation</b>	216 gpm	214-216 gpm
<b>Fault Level 1</b>	10% reduction in flow (194 gpm)	194-196 gpm
<b>Fault Level 2</b>	20% reduction in flow (173 gpm)	175-177 gpm
<b>Fault Level 3</b>	30% reduction in flow (151 gpm)	155-156 gpm
<b>Fault Level 4</b>	40% reduction in flow (130 gpm)	137-141 gpm

Due to difficulties in fine-tuning the valve position, the actual flow rate was more difficult to obtain at lower flow rates. Consequently it can be seen that the actual reduction in flow for Fault Level 2 was 19%, for Fault Level 3 it was 28%, and for Fault Level 4 it was 36%.

The following tables also include extra tests at the second and fourth fault levels, FWE20 alt and FWE40 alt, which did not meet the operating conditions as well as FWE20 and FWE40.

**Table 2.29: FWE10 test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.41	49.50	85.51	94.96	104.72	89.05	82.47	266	196	36.74	123.40	8.86	45.92	4.20	123.76	24.14
2	57.48	50.67	85.26	91.18	66.22	55.59	57.86	269	196	38.22	112.70	6.32	48.58	5.42	128.62	34.30
3	54.10	50.58	85.10	88.39	36.84	28.54	42.04	269	195	39.42	104.80	4.42	49.96	5.70	146.06	55.86
4	61.25	49.92	75.41	85.15	107.52	92.06	71.26	265	195	36.16	105.50	9.20	45.98	4.94	113.44	22.82
5	56.48	50.03	74.73	80.39	62.75	52.56	47.85	266	196	37.32	92.70	5.78	47.82	5.64	119.20	35.82
6	53.02	50.15	74.98	77.69	30.22	23.31	34.26	267	195	39.26	85.10	3.10	49.86	5.82	144.54	65.66
7	58.65	49.47	69.81	77.60	86.42	74.68	55.54	266	195	36.50	90.30	7.46	46.40	5.00	109.32	27.18
8	56.05	49.86	65.28	70.47	57.87	50.47	41.21	267	195	35.84	76.70	5.58	47.74	6.96	111.88	38.18
9	53.46	49.91	62.46	65.53	34.50	29.02	32.16	270	196	37.06	67.50	3.56	49.14	7.14	126.18	58.80
10	56.13	45.95	85.32	94.14	98.24	83.14	80.63	267	196	34.64	120.30	7.62	42.96	3.42	123.12	25.06
11	51.75	45.16	85.35	91.23	65.81	53.60	59.15	268	195	34.84	112.60	6.16	43.28	3.52	127.28	32.98
12	49.28	45.54	85.10	88.68	40.14	30.26	44.69	269	195	36.18	105.60	4.76	44.88	3.86	140.52	49.70
13	56.36	45.00	75.25	85.09	109.74	92.70	74.90	268	196	33.24	105.60	8.96	41.58	3.46	112.00	21.42
14	50.88	44.34	75.32	81.09	64.63	53.34	50.75	268	196	33.88	94.30	5.98	42.48	3.70	116.76	32.56
15	48.32	45.21	75.08	78.05	33.26	25.36	36.47	269	196	36.06	86.30	3.62	44.86	3.94	137.16	57.42
16	56.40	45.13	70.99	80.68	107.54	91.64	69.84	266	195	32.86	97.60	8.92	41.50	4.02	108.20	22.06
17	51.49	44.08	65.59	71.94	71.08	60.16	47.36	269	195	32.90	79.80	6.06	41.78	4.16	105.70	29.92
18	48.91	45.17	66.00	69.33	37.21	30.34	34.85	269	195	35.26	73.60	3.64	44.60	4.40	123.20	51.82
19	50.68	40.28	80.82	89.86	100.78	84.75	79.29	267	195	31.78	110.10	7.28	37.04	0.64	116.36	23.54
20	46.79	40.13	80.33	86.31	66.78	53.97	56.55	268	194	32.38	103.50	6.66	39.06	2.00	119.50	29.98
21	43.95	40.02	80.30	84.03	41.98	31.99	43.57	270	195	33.04	96.40	3.68	39.78	2.02	130.98	45.62
22	52.18	40.07	70.63	81.04	114.96	98.47	77.07	265	195	30.40	98.90	9.78	36.98	2.12	107.10	20.24
23	46.37	39.30	70.69	76.83	69.02	57.38	50.47	269	195	31.44	87.30	6.76	38.04	2.00	108.60	28.14
24	43.77	40.09	71.06	74.52	38.78	29.77	37.96	270	194	32.44	81.20	4.02	39.82	2.68	124.44	47.94
25	50.42	39.79	66.63	75.72	101.28	86.43	63.37	267	195	30.26	88.30	9.10	37.24	2.48	102.50	21.42
26	47.25	40.16	65.04	71.24	69.29	57.65	46.76	268	195	31.38	78.90	6.56	38.66	2.74	103.86	28.86
27	43.68	39.98	64.83	68.33	39.17	30.08	35.12	268	195	32.00	71.90	4.06	39.52	2.86	118.14	47.72

**Table 2.30: FWE20 alt test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	61.03	48.98	85.80	94.97	101.76	86.35	81.62	266	172	36.26	124.50	9.20	45.36	4.28	124.02	23.92
2	57.90	50.36	85.40	91.18	64.65	53.97	57.53	268	172	37.66	112.60	6.52	48.00	5.44	129.24	34.84
3	54.03	50.06	85.36	88.68	37.36	28.42	42.55	270	172	39.04	105.00	4.42	49.42	5.50	145.86	55.32
4	62.10	49.81	75.83	85.18	103.24	88.25	69.29	265	172	35.94	105.10	8.86	45.82	5.00	113.84	23.36
5	57.75	51.65	74.46	79.42	55.18	43.69	49.82	267	172	37.72	94.22	6.12	48.48	6.08	123.16	38.90
6	53.48	50.31	75.38	78.07	29.96	22.72	34.82	267	172	38.96	86.00	3.24	49.94	6.16	145.50	66.04
7	59.43	49.15	70.70	78.50	86.36	73.54	56.18	266	172	35.98	91.50	7.14	45.92	5.02	109.92	27.20
8	56.56	49.96	65.78	70.81	55.99	47.36	40.57	267	172	36.74	77.20	5.36	47.92	6.32	112.98	38.94
9	54.16	49.97	64.24	67.52	36.84	29.97	33.68	270	172	37.46	70.80	3.80	49.06	6.70	125.38	55.56
10	56.32	45.08	85.59	94.22	96.42	80.39	79.64	268	172	34.38	122.20	8.16	42.28	3.04	123.16	24.18
11	52.58	45.31	85.58	91.29	63.98	52.04	58.66	269	172	34.72	112.60	5.96	43.28	3.64	128.20	34.16
12	49.59	45.43	85.26	88.75	39.12	29.81	43.96	269	172	35.80	104.90	4.52	44.62	3.90	141.86	51.22
13	57.23	45.01	75.58	84.89	103.54	87.61	71.33	267	172	33.40	104.30	8.56	41.58	3.42	112.00	21.96
14	51.64	44.46	75.72	81.32	62.85	51.55	50.30	269	172	33.92	94.50	5.84	42.42	3.70	117.48	33.02
15	48.46	45.02	75.29	78.22	32.89	24.57	36.45	269	172	35.72	86.70	3.62	44.62	3.90	137.74	57.84
16	57.47	45.11	71.58	80.94	103.90	88.53	68.16	266	172	32.94	97.80	8.64	41.50	3.88	108.60	22.26
17	51.93	44.21	65.64	71.52	66.12	55.35	45.15	270	172	33.52	79.10	6.08	42.08	3.64	106.58	31.50
18	49.03	45.13	65.78	68.97	35.82	27.84	33.97	269	171	35.32	72.50	3.70	44.48	4.22	125.04	54.16
19	51.43	40.18	80.60	89.13	95.51	80.15	74.91	269	171	31.46	108.00	6.82	36.78	0.74	115.72	23.98
20	47.41	40.12	80.30	86.05	64.33	52.12	55.35	268	171	32.20	102.96	6.40	38.78	1.84	120.08	30.90
21	44.49	40.13	80.34	84.06	41.71	31.11	43.56	269	171	32.74	96.40	3.90	39.76	2.24	131.58	45.98
22	52.57	39.72	70.38	80.07	107.58	91.93	71.16	266	172	30.34	96.50	9.68	35.80	0.86	105.42	19.84
23	46.80	39.29	70.20	75.99	64.99	53.78	48.72	270	172	31.26	85.90	6.60	37.82	2.02	109.00	29.54
24	44.16	40.19	70.18	73.53	37.68	28.41	36.88	270	171	32.46	79.20	3.68	39.76	2.64	124.74	49.50
25	49.88	39.47	64.29	72.08	87.15	74.56	55.06	269	172	29.76	81.50	7.86	36.98	2.82	100.94	24.38
26	46.86	39.95	62.34	67.62	59.25	49.37	41.78	269	171	30.46	72.70	5.64	38.32	3.50	104.22	33.30
27	43.51	40.01	61.23	64.21	33.55	25.09	31.59	270	172	32.38	65.30	2.60	39.76	2.72	120.18	54.42

**Table 2.31: FWE20 test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	61.23	49.94	85.58	94.41	97.93	82.75	77.94	266	176	36.26	119.50	7.12	46.10	4.92	124.04	26.42
2	57.75	50.52	85.34	91.05	63.78	53.09	56.82	268	176	37.92	112.50	6.32	48.26	5.48	129.64	35.38
3	54.31	50.49	85.27	88.50	36.23	27.97	42.01	269	176	38.74	105.00	4.26	49.72	6.08	147.00	56.70
4	61.42	49.47	75.59	84.89	102.24	87.79	68.59	264	176	36.02	104.40	8.78	45.60	4.68	113.58	23.46
5	57.55	50.42	75.80	81.36	61.93	52.20	48.85	267	176	37.12	95.00	6.04	48.08	6.06	120.52	35.74
6	53.21	50.03	75.36	78.11	30.75	23.30	35.02	268	176	38.74	86.20	3.34	49.56	6.06	144.04	64.50
7	59.39	49.15	70.73	78.65	87.85	75.01	57.10	266	176	35.78	92.20	7.38	45.86	5.10	109.98	26.90
8	56.57	49.91	65.86	71.02	57.41	48.72	41.01	267	176	35.98	77.30	5.58	47.66	6.82	112.94	38.90
9	54.18	50.01	64.17	67.51	37.48	30.58	33.48	269	176	37.42	70.70	3.74	49.04	6.72	124.76	55.22
10	56.42	45.48	85.53	94.15	95.74	80.09	79.31	267	176	34.48	122.00	8.12	42.56	3.12	123.32	24.32
11	52.45	45.20	85.62	91.49	65.78	52.98	59.46	269	175	34.72	113.20	6.30	43.08	3.46	127.64	33.02
12	49.13	45.07	85.29	88.83	39.82	29.79	44.60	270	176	35.82	105.50	4.56	44.36	3.60	141.06	50.24
13	57.34	45.33	75.56	84.89	103.80	87.96	71.93	267	176	33.16	104.90	8.76	41.70	3.88	112.28	22.08
14	51.90	44.71	75.79	81.50	63.99	52.64	50.81	269	176	34.22	95.10	5.78	42.70	3.66	117.28	32.62
15	48.34	44.95	75.24	78.20	33.22	24.80	36.09	269	176	35.86	86.40	3.52	44.60	3.92	137.16	57.30
16	56.64	44.91	70.66	79.74	100.44	86.41	65.28	266	177	33.50	95.20	8.56	41.66	3.46	107.42	22.36
17	51.71	44.27	65.10	70.88	65.10	54.51	44.44	270	176	33.02	77.88	6.02	41.98	4.28	106.66	32.20
18	49.04	45.37	64.86	67.93	34.54	26.97	33.10	271	176	35.02	71.10	3.70	44.82	4.82	126.04	56.18
19	51.32	40.88	79.07	87.21	91.15	76.48	69.33	269	176	31.66	108.00	8.42	38.46	2.16	114.24	22.28
20	47.45	40.37	80.01	85.80	64.68	51.69	55.06	269	175	32.18	107.52	6.22	39.16	2.30	120.02	31.22
21	44.15	39.97	80.01	83.70	41.46	30.68	42.87	270	176	32.66	95.80	3.80	39.60	2.28	131.88	46.56
22	52.63	40.55	69.88	79.14	102.62	88.38	67.97	266	176	30.62	95.00	9.28	37.52	2.42	105.54	20.72
23	46.36	39.32	68.74	74.29	62.41	51.63	46.53	270	176	31.18	82.80	6.14	38.00	2.34	108.56	30.98
24	43.86	40.07	69.17	72.44	36.78	27.81	36.31	270	176	32.30	77.98	3.80	39.78	2.80	124.62	50.22
25	49.27	39.74	62.93	70.28	82.28	69.80	51.53	269	176	30.46	78.54	7.50	37.54	2.72	100.22	25.50
26	46.82	40.44	61.28	66.28	56.25	46.82	40.06	270	176	30.46	70.70	5.42	38.70	3.78	104.58	35.06
27	43.30	39.95	60.50	63.44	33.08	24.70	31.21	270	177	32.26	64.20	2.78	39.72	2.78	120.54	55.46

Table 2.32: FWE30 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	62.40	50.60	85.16	93.17	89.15	76.20	71.62	267	155	36.60	118.90	8.12	46.68	5.16	123.58	26.02
2	58.67	50.77	85.06	90.56	61.54	51.18	55.65	269	156	37.74	111.30	6.16	48.30	5.66	130.28	36.70
3	54.82	50.73	83.86	86.99	35.21	26.40	40.69	270	155	38.88	102.00	4.06	49.84	6.28	147.52	58.72
4	62.74	50.05	75.44	84.12	95.94	81.85	65.77	265	155	35.32	102.58	8.34	45.76	5.52	114.28	25.18
5	57.89	50.04	75.33	80.85	61.24	50.50	48.31	266	155	37.02	93.70	5.78	47.60	5.66	120.18	36.22
6	54.12	50.78	74.92	77.52	28.93	21.65	34.40	267	156	39.00	85.50	3.42	50.26	6.40	146.88	67.78
7	60.65	49.95	70.30	77.57	80.64	69.08	53.47	266	155	36.18	89.80	7.00	46.56	5.40	110.46	28.80
8	56.73	50.12	65.28	69.86	51.15	42.83	38.46	268	155	36.82	75.20	5.02	48.10	6.40	114.76	41.98
9	53.93	49.96	62.47	65.38	32.69	25.69	31.30	270	155	37.46	67.20	3.14	49.16	6.88	129.00	61.90
10	57.07	45.42	84.96	93.01	89.63	75.28	73.94	267	155	33.88	118.50	7.58	42.32	3.52	122.32	25.24
11	53.67	45.84	85.24	90.76	61.64	50.54	57.29	268	155	34.76	111.40	5.96	43.64	3.96	128.54	35.00
12	49.38	45.02	82.85	86.26	38.41	28.14	42.56	270	155	35.28	101.00	4.22	44.02	3.74	140.36	52.26
13	57.95	45.25	75.24	83.94	96.80	82.14	67.44	267	155	32.98	102.40	8.18	41.56	3.90	112.08	23.22
14	51.60	44.27	74.65	79.87	58.48	47.23	47.79	269	155	33.88	91.50	5.30	42.32	3.66	117.86	35.14
15	48.50	44.96	74.09	76.90	31.52	22.95	35.32	270	155	35.72	84.60	3.40	44.44	3.68	138.42	59.70
16	56.39	44.53	69.86	77.96	90.21	76.59	59.20	267	155	33.02	91.30	7.62	41.34	3.60	107.18	24.58
17	51.67	44.23	64.28	69.43	57.84	48.10	41.51	270	155	33.18	75.10	5.52	42.04	4.12	107.88	35.24
18	49.01	45.08	64.33	67.25	32.87	25.40	32.31	271	155	34.96	70.10	3.20	44.52	4.56	127.34	58.30
19	51.58	40.72	79.07	86.55	83.45	70.06	64.76	268	155	31.66	106.00	8.04	38.20	1.96	114.36	23.60
20	47.87	40.17	79.86	85.39	62.05	49.75	53.61	269	155	32.16	101.40	6.46	38.66	1.92	120.28	31.90
21	44.72	40.07	79.88	83.48	40.52	30.09	42.19	270	155	32.94	94.90	3.18	39.44	1.88	131.78	47.28
22	52.97	40.42	70.07	78.63	95.18	81.02	63.30	267	155	30.46	92.80	8.68	37.22	2.28	105.46	21.90
23	46.90	39.33	68.79	74.09	59.83	48.97	45.71	271	155	30.78	82.50	5.86	37.76	2.44	109.60	32.44
24	44.24	40.00	69.97	73.22	36.57	27.47	36.06	271	155	32.58	77.96	2.68	39.56	2.28	124.42	50.08
25	50.29	39.96	63.94	70.97	78.78	66.65	50.71	269	155	30.42	79.20	7.28	37.60	2.60	101.18	26.00
26	47.84	40.07	64.16	69.56	60.57	50.16	42.86	269	155	31.08	75.40	6.14	38.50	2.82	105.14	32.14
27	44.23	40.15	62.82	65.93	35.03	26.28	32.95	270	155	31.74	68.20	3.40	39.70	3.38	120.64	52.96

Table 2.33: FWE40 alt test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	63.70	50.37	85.47	93.29	86.82	73.41	70.24	266	132	36.24	119.50	7.74	46.30	5.14	123.78	26.16
2	59.38	50.78	85.27	90.48	58.34	47.41	54.32	269	132	37.40	110.70	5.76	48.08	5.78	131.66	38.38
3	55.05	50.23	85.13	88.26	35.10	26.51	41.42	269	132	38.34	104.40	4.26	49.14	5.86	147.84	57.94
4	63.42	50.07	75.50	83.38	86.91	73.54	60.85	265	132	35.48	100.40	7.50	45.80	5.28	114.60	26.74
5	59.28	50.78	75.42	80.53	56.95	46.79	46.57	268	132	37.14	92.90	5.54	48.12	6.04	122.32	38.84
6	54.15	50.39	75.23	77.74	27.98	20.74	34.19	267	133	38.78	85.60	3.00	49.86	6.24	147.74	68.56
7	60.83	49.70	70.23	76.75	72.30	61.55	49.86	266	133	35.92	87.80	6.60	46.18	5.38	111.36	30.68
8	57.44	51.22	64.84	68.67	42.68	34.33	34.65	267	132	40.50	73.00	3.84	49.20	4.00	122.22	51.14
9	54.64	50.57	62.53	65.13	29.34	22.47	30.31	271	132	37.96	66.50	2.60	49.84	6.98	134.46	67.92
10	58.81	45.65	85.51	93.32	87.04	72.10	72.40	267	132	34.00	119.30	7.76	42.24	3.36	122.82	25.36
11	54.54	45.62	85.56	91.04	61.46	49.07	57.28	269	132	34.42	111.90	6.06	43.28	3.94	129.24	35.36
12	50.39	45.19	85.27	88.71	38.73	28.48	44.11	270	131	35.42	105.30	4.56	44.02	3.58	141.94	51.48
13	58.43	45.04	75.40	83.26	87.56	73.98	62.38	267	133	33.16	100.40	7.84	41.44	3.62	112.42	24.62
14	52.76	44.43	75.08	80.14	56.83	45.90	47.29	269	132	33.82	92.00	5.54	42.32	3.56	119.06	36.18
15	49.33	45.23	75.24	78.02	31.38	22.57	35.69	271	132	35.74	86.00	3.44	44.48	3.78	139.84	60.42
16	57.76	44.78	70.42	78.01	84.67	71.51	56.59	268	132	33.42	90.72	7.54	41.48	3.24	107.82	25.64
17	52.45	44.18	65.19	70.13	55.59	45.52	41.22	270	132	32.50	76.30	5.48	41.74	4.56	109.98	36.62
18	50.09	45.70	65.52	68.43	32.92	24.21	32.59	271	132	35.26	71.30	3.40	44.82	4.52	129.12	58.98
19	53.36	40.36	80.79	88.39	85.06	71.32	69.13	269	132	31.14	106.20	6.62	36.46	0.90	111.82	20.92
20	48.91	40.04	80.16	85.53	60.35	48.70	53.80	270	132	31.94	100.90	5.30	37.42	0.84	119.56	31.50
21	45.54	40.03	80.23	83.80	40.29	30.38	42.42	271	132	32.88	95.00	2.64	38.82	1.26	131.20	46.54
22	54.16	40.77	70.62	78.41	86.99	73.66	59.63	268	132	30.72	91.60	7.98	37.12	1.90	105.02	22.26
23	48.39	39.44	70.89	76.19	59.45	49.40	47.04	269	133	30.86	85.60	5.88	37.10	1.70	110.74	31.54
24	45.01	40.14	70.71	73.91	36.12	26.85	36.15	271	133	32.62	78.50	2.18	39.24	1.96	125.48	50.72
25	52.61	40.91	66.25	73.10	76.97	64.72	50.84	270	133	30.94	82.10	7.26	37.88	2.48	103.50	26.48
26	49.11	40.22	65.70	71.02	59.57	48.93	43.70	269	132	30.68	77.70	5.96	38.08	2.98	107.10	32.94
27	45.53	40.54	65.56	68.81	36.59	27.55	34.40	270	133	32.24	72.00	3.12	39.82	2.92	121.08	50.54

**Table 2.34: FWE40 test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	63.00	50.13	85.61	93.64	89.05	75.62	71.43	266	141	36.60	120.30	8.02	46.18	4.68	123.38	25.40
2	58.99	50.74	85.39	90.72	59.60	48.46	54.82	268	141	37.86	111.30	5.86	48.16	5.46	131.04	37.52
3	55.19	50.76	85.26	88.35	34.63	26.02	41.37	269	141	39.00	104.30	4.04	49.72	6.00	148.68	58.80
4	62.55	49.55	75.70	83.80	89.77	76.49	62.01	266	141	35.70	101.40	7.74	45.60	4.80	114.00	20.62
5	58.99	50.85	75.80	81.02	58.30	47.86	47.41	268	141	37.50	93.70	5.60	48.30	6.02	122.34	38.24
6	53.83	50.08	75.48	78.14	29.84	22.11	34.75	268	141	38.92	86.20	3.40	49.56	5.96	145.72	66.00
7	60.87	50.04	70.61	77.32	74.49	63.77	51.65	267	141	35.94	89.00	6.68	46.58	5.74	111.70	30.46
8	57.00	49.98	65.64	70.00	48.76	40.12	37.55	269	137	36.76	75.10	4.84	47.90	6.28	116.68	43.96
9	54.64	50.41	63.16	65.94	31.28	24.07	31.06	271	137	38.02	67.60	2.92	49.60	6.68	131.88	64.36
10	58.68	45.60	85.70	93.66	89.04	74.72	74.27	268	137	34.18	120.30	8.04	42.26	3.34	123.08	25.06
11	54.60	45.92	85.68	91.18	61.72	49.68	57.56	269	137	34.60	112.20	5.92	43.56	4.14	129.42	35.60
12	50.08	45.16	85.22	88.58	37.83	27.97	43.44	270	137	35.46	105.00	4.46	44.14	3.66	142.84	52.46
13	58.55	45.16	75.73	83.85	90.72	76.60	64.11	268	137	33.46	101.60	8.14	41.70	3.42	112.34	23.90
14	52.54	44.17	75.55	80.81	59.00	47.78	48.45	269	137	33.74	93.30	5.90	42.16	3.64	118.40	34.66
15	49.17	45.13	75.44	78.31	32.21	23.01	36.11	269	137	35.56	86.70	3.52	44.36	3.80	139.28	59.12
16	58.16	45.25	70.93	78.69	86.49	73.45	58.72	267	137	33.42	92.40	7.70	41.78	3.56	108.52	25.22
17	52.55	44.15	65.62	70.78	58.03	48.06	42.47	270	137	32.44	77.40	5.62	41.58	4.52	109.36	35.28
18	49.80	45.31	65.65	68.69	34.34	25.64	33.12	271	137	35.32	71.90	3.44	44.40	4.06	127.22	56.62
19	53.06	40.42	80.72	88.38	85.85	71.90	69.10	269	137	31.22	109.20	8.08	36.56	0.90	114.52	22.18
20	48.66	40.20	80.09	85.44	60.11	48.18	53.08	269	137	31.82	101.00	5.96	38.04	1.62	120.90	32.66
21	45.11	40.01	80.10	83.61	39.61	29.27	42.02	271	138	32.42	95.10	3.36	39.16	2.06	133.08	48.30
22	53.60	40.42	70.38	78.33	88.17	75.39	59.96	266	137	30.74	91.50	8.28	36.62	1.36	105.54	23.04
23	48.32	39.75	70.42	75.72	59.67	48.81	46.45	270	137	31.20	84.70	5.98	37.80	2.10	111.14	32.40
24	44.77	40.25	70.28	73.37	34.88	25.85	35.65	271	137	32.18	78.44	2.94	39.64	2.78	127.22	52.58
25	51.39	40.10	65.49	72.31	76.28	64.46	51.23	268	137	30.38	81.00	7.48	37.20	2.44	102.82	26.42
26	49.04	40.53	65.40	70.65	58.83	48.47	43.20	269	137	30.80	77.40	5.92	38.58	3.28	107.38	33.36
27	44.93	40.14	65.03	68.25	36.14	27.43	34.25	269	137	31.80	70.90	3.40	39.44	2.90	120.82	50.66

## 2.3 Refrigerant Leak

Removing refrigerant from the system simulated the refrigerant leak. The base refrigerant charge in the system was 300 pounds. Each fault level reduced the refrigerant charge by 10% as shown in Table 2.35. The system was initially brought to a vacuum before charging it to 180 pounds (Fault Level 4). The fault tests were run in reverse order, with each successive test adding 30 pounds of refrigerant. The amount of refrigerant added was weighed on an industrial scale with an uncertainty of  $\pm 0.5$  pounds.

**Table 2.35: Fault levels for refrigerant leak**

<b>Case</b>	<b>Desired Condition</b>	<b>Actual Charge</b>
<b>Normal Operation</b>	300 lbs refrigerant	300 lbs
<b>Fault Level 1</b>	10% reduction in charge	270 lbs
<b>Fault Level 2</b>	20% reduction in charge	240 lbs
<b>Fault Level 3</b>	30% reduction in charge	210 lbs
<b>Fault Level 4</b>	40% reduction in charge	180 lbs

The error in the actual charge is less than 1%. Each additional 30 pounds of refrigerant was measured from the same recovery tank. Thus the actual amount of refrigerant added was based on a single reference point, rather than on the last charge level. The following tables also include an extra test at the fourth fault level, RL40 alt, which did not meet the operating conditions as well as RL40.

**Table 2.36: RL10 test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	61.46	51.40	86.00	95.46	105.52	90.64	83.76	268	216	37.24	125.90	9.12	47.78	5.62	125.58	24.70
2	56.85	50.50	85.43	91.44	67.41	57.09	58.56	269	216	37.84	114.00	6.76	48.54	5.70	128.82	33.98
3	53.48	50.08	85.65	89.06	38.40	30.54	43.17	270	215	38.96	106.20	4.70	49.56	5.78	145.50	54.48
4	60.34	50.07	75.38	85.03	106.82	92.55	71.02	266	216	35.94	105.70	9.36	46.48	5.60	114.26	23.56
5	56.52	50.07	75.92	82.00	67.79	57.81	51.46	267	215	36.94	96.70	6.58	48.00	6.24	119.38	33.58
6	53.18	50.41	75.77	78.57	31.20	24.89	35.44	268	215	38.90	87.60	3.76	50.04	6.30	144.18	63.66
7	59.02	49.77	70.68	79.22	94.98	83.25	60.74	267	216	35.68	94.20	8.20	46.68	5.96	110.62	26.46
8	55.96	49.80	65.50	71.16	63.40	55.25	42.85	269	215	36.74	78.60	6.12	47.92	6.16	110.74	36.08
9	53.74	50.00	63.57	67.01	38.97	33.57	34.05	271	215	36.14	70.50	4.04	49.02	7.98	123.88	54.44
10	56.01	46.85	85.36	94.05	97.37	82.53	79.77	269	216	34.62	122.50	8.68	43.88	4.30	124.02	25.00
11	51.43	45.18	86.08	92.15	68.42	56.11	61.40	270	216	35.12	115.26	6.88	43.60	3.48	127.28	31.92
12	48.64	45.10	85.58	89.23	41.18	31.79	45.50	271	215	35.92	107.00	5.02	44.64	3.80	140.70	49.20
13	57.34	46.43	76.16	86.52	115.50	98.42	81.19	267	216	33.36	109.20	9.86	42.64	4.52	114.90	22.32
14	50.98	44.80	76.06	81.97	66.24	55.57	52.11	269	216	33.92	96.40	6.34	42.98	4.06	117.68	32.20
15	48.38	45.41	75.62	78.64	33.99	26.56	37.02	270	216	36.10	87.70	3.86	45.26	4.26	137.86	57.26
16	56.47	45.81	71.20	81.18	111.40	95.82	72.36	268	216	33.46	99.80	9.88	42.32	4.08	108.92	21.52
17	51.58	44.24	66.25	73.19	78.08	66.11	50.48	270	216	33.26	83.40	7.60	41.92	3.90	105.62	27.82
18	48.76	45.26	66.34	69.82	39.26	31.26	35.35	271	215	35.46	74.70	4.22	44.74	4.32	122.72	50.54
19	51.47	42.44	80.85	89.44	96.23	81.18	76.33	269	216	31.58	112.80	8.78	39.80	3.58	118.82	24.34
20	46.44	40.01	81.13	87.39	70.45	57.64	58.07	270	215	32.48	104.20	5.88	39.02	1.82	117.76	27.82
21	43.90	40.33	80.85	84.62	42.52	31.99	43.44	270	215	33.40	96.20	2.06	40.08	1.90	130.44	45.20
22	52.80	41.75	71.10	81.49	115.36	99.47	77.68	267	216	30.98	100.20	11.22	38.74	3.22	108.80	21.20
23	46.43	39.55	71.39	77.96	73.77	61.88	52.79	270	216	31.06	89.00	6.46	38.24	2.72	108.16	26.86
24	43.57	40.13	71.45	75.09	41.19	30.66	38.08	271	215	33.06	80.60	1.92	39.98	2.24	122.34	46.24
25	51.01	40.65	67.72	77.31	107.16	92.94	68.31	268	215	30.16	91.60	10.18	37.84	3.30	104.22	21.48
26	47.62	40.47	66.29	73.08	76.23	63.97	50.12	270	215	31.48	81.70	6.84	38.90	2.86	103.66	26.82
27	43.57	39.87	66.04	69.85	42.88	33.13	36.39	270	215	32.78	72.90	2.38	39.68	2.24	114.94	43.80

Table 2.37: RL20 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	61.38	51.12	86.35	96.06	107.74	92.22	85.12	266	216	37.66	127.20	10.72	47.62	5.18	125.16	23.84
2	57.17	50.68	85.80	91.86	67.99	58.17	59.44	269	215	38.04	114.58	6.94	48.78	5.80	128.44	33.52
3	53.35	49.95	85.92	89.32	38.07	30.60	43.27	269	216	39.20	106.30	4.36	49.46	5.44	144.62	53.68
4	61.38	50.16	76.21	86.84	117.22	101.02	77.60	265	216	36.10	109.60	11.36	46.34	5.38	114.74	22.10
5	56.63	50.09	76.34	82.56	69.23	58.53	51.73	267	215	37.24	96.70	6.58	47.96	5.96	118.88	33.14
6	53.03	50.19	76.04	78.87	31.49	25.50	35.77	268	216	38.08	87.80	3.64	49.88	6.92	143.92	63.20
7	59.14	49.62	71.45	80.34	98.32	85.57	62.55	265	216	35.84	95.30	9.02	46.38	5.54	110.34	25.38
8	56.28	49.84	66.28	72.16	65.64	57.85	44.52	268	215	35.72	79.90	6.26	47.68	6.96	110.66	34.96
9	53.80	49.96	64.22	67.78	40.18	34.49	34.30	270	216	37.12	70.90	3.80	49.04	7.00	122.36	52.38
10	56.47	47.32	85.59	94.29	97.11	82.24	79.69	268	216	34.60	122.30	9.80	44.28	4.52	124.44	25.10
11	51.86	45.58	86.25	92.36	68.36	56.31	61.25	268	215	35.06	114.90	6.44	43.84	3.80	126.92	31.60
12	49.57	45.99	85.82	89.44	40.81	32.11	45.74	270	215	35.94	106.40	4.28	45.52	4.68	141.24	50.12
13	57.74	46.58	76.32	86.88	117.32	100.53	82.13	267	216	33.54	109.70	11.20	42.74	4.38	114.72	22.18
14	50.88	44.62	76.20	82.19	67.36	56.18	52.24	269	215	34.16	95.90	5.90	42.90	3.88	116.78	31.44
15	48.29	45.25	75.83	78.86	34.08	27.16	37.28	270	215	35.32	87.70	3.52	44.98	4.66	137.04	56.34
16	57.76	46.39	72.91	83.61	118.50	102.22	79.46	266	216	32.98	103.82	11.52	42.38	4.70	111.62	21.88
17	51.72	44.39	66.29	73.13	76.76	65.82	49.71	269	215	32.92	81.80	6.68	42.08	4.50	105.26	28.50
18	48.55	44.95	66.46	70.04	40.27	32.26	35.59	270	215	34.92	74.10	3.32	44.40	4.48	121.98	50.20
19	51.50	42.03	81.14	90.12	100.45	84.67	78.06	269	215	31.96	111.90	8.46	39.72	3.18	117.22	23.28
20	46.94	40.82	80.59	86.55	66.98	54.61	56.29	270	214	32.28	102.58	5.62	39.68	2.66	118.56	29.56
21	43.54	40.07	80.25	83.97	41.95	31.00	42.89	271	214	33.04	94.50	1.00	39.92	2.06	130.10	45.74
22	52.56	41.63	70.41	80.68	114.28	97.77	75.16	267	215	30.22	96.80	9.66	38.14	3.44	106.82	21.18
23	45.83	39.36	70.12	76.32	69.90	58.05	49.44	271	216	31.38	84.30	3.92	38.24	2.48	106.02	27.54
24	43.52	40.24	70.32	73.76	38.73	29.35	36.84	271	215	32.66	79.00	2.48	39.90	2.50	123.32	48.22
25	49.59	40.12	65.11	73.92	98.91	84.94	60.16	269	215	30.12	82.70	7.30	37.72	3.22	99.98	22.62
26	47.68	40.90	65.39	71.75	71.29	60.65	48.21	269	214	30.34	79.10	6.30	38.86	4.00	104.06	28.92
27	43.87	40.34	64.86	68.43	40.27	31.62	35.25	271	215	31.86	71.20	3.28	39.88	3.50	117.26	47.44

Table 2.38: RL30 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	61.19	50.68	86.37	96.32	110.24	94.47	85.61	266	216	37.16	124.50	9.20	47.04	4.94	123.58	23.34
2	57.05	50.62	85.71	91.79	67.97	57.58	58.05	268	215	38.18	112.00	5.52	48.68	5.58	127.04	33.04
3	53.82	50.41	85.88	89.28	38.10	30.67	42.79	269	216	39.24	105.10	3.44	49.82	5.70	144.70	54.42
4	61.33	49.92	76.26	87.14	119.60	102.86	77.71	264	216	35.86	106.60	9.54	45.94	5.18	113.14	21.78
5	57.38	50.80	76.34	82.58	69.18	59.20	50.89	266	216	37.34	95.20	5.40	48.66	6.46	118.30	33.38
6	53.17	50.34	76.10	78.93	31.36	25.38	35.57	266	216	39.14	87.00	2.70	50.04	6.20	142.64	62.50
7	59.08	49.39	71.53	80.64	100.42	86.90	62.65	264	215	35.82	93.80	7.36	46.22	5.46	108.76	24.96
8	56.56	50.25	66.26	72.03	64.28	56.77	43.13	267	216	36.18	77.88	4.88	48.18	7.10	110.22	35.88
9	53.80	49.88	64.39	68.03	40.98	35.28	34.52	270	215	37.20	70.50	2.74	48.96	6.92	120.86	51.22
10	56.65	47.14	86.05	95.13	101.08	85.16	81.20	267	215	34.88	121.40	8.28	44.02	4.18	122.62	24.00
11	51.95	45.69	86.20	92.30	68.28	56.16	60.06	269	215	35.34	112.60	5.20	43.94	3.58	125.38	31.14
12	48.85	45.31	85.59	89.20	40.54	31.75	44.73	270	216	36.26	105.00	3.24	44.88	3.84	139.70	49.74
13	56.77	45.56	76.22	86.91	118.86	100.62	81.42	267	215	33.08	106.20	9.04	41.92	4.12	112.44	21.24
14	50.89	44.76	76.18	82.12	66.34	54.87	50.85	268	215	34.52	93.70	4.58	43.02	3.40	115.38	31.50
15	48.13	45.19	75.80	78.79	33.48	26.35	36.82	269	215	36.22	86.50	2.28	45.10	4.06	136.02	56.22
16	56.51	45.49	71.67	82.11	115.62	99.21	73.57	266	216	33.10	97.20	8.34	41.84	3.90	107.20	21.40
17	51.44	44.05	66.29	73.23	77.95	66.37	49.68	269	216	32.84	80.00	5.54	41.78	4.32	103.98	28.12
18	49.05	45.61	66.33	69.75	38.52	30.86	34.92	270	215	35.28	72.60	2.44	44.98	4.70	123.06	52.02
19	50.95	41.21	81.33	90.66	103.98	87.04	79.30	268	215	31.64	110.30	5.34	38.98	2.70	115.18	22.14
20	46.57	40.34	81.11	87.26	69.13	55.96	57.12	270	215	32.24	101.90	1.10	39.28	2.26	116.86	28.16
21	43.93	40.39	80.65	84.37	41.90	31.72	43.34	270	215	32.54	95.70	2.20	39.94	2.70	131.30	46.10
22	52.70	41.15	71.26	82.30	122.16	103.48	80.83	266	215	30.48	96.50	6.26	37.96	3.04	106.74	21.08
23	46.42	39.71	71.29	77.76	72.48	60.13	51.33	269	215	31.34	85.60	0.82	38.36	2.52	106.26	26.94
24	43.89	40.55	71.34	74.81	39.14	29.93	37.42	270	215	32.40	80.20	2.10	40.08	2.92	123.88	48.04
25	50.58	40.23	67.33	77.09	108.80	92.71	66.75	267	215	30.38	86.30	3.94	37.70	2.88	100.82	20.94
26	47.24	40.01	66.27	73.14	76.69	64.76	49.81	268	215	30.74	79.10	3.50	38.20	2.96	101.58	26.38
27	43.68	40.08	66.06	69.78	41.47	32.21	36.05	268	215	32.42	72.10	1.02	39.56	2.42	115.22	44.44

**Table 2.39: RL40 alt test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	59.72	49.25	85.64	95.58	110.22	94.06	82.37	266	216	37.44	120.10	5.48	45.98	3.64	119.28	21.28
2	56.86	50.51	85.26	91.30	67.49	57.10	56.96	268	216	38.54	109.60	3.34	48.56	5.26	125.48	32.84
3	54.03	50.67	82.58	86.19	40.38	30.10	42.46	269	215	41.16	101.36	2.82	49.12	3.26	146.96	58.42
4	60.85	49.74	75.49	86.02	115.96	99.87	73.52	264	216	36.70	102.30	5.68	46.02	4.42	110.50	21.54
5	57.01	51.54	73.53	78.80	58.70	49.03	42.99	267	215	40.64	87.06	2.82	49.12	3.94	120.50	40.30
6	53.03	50.45	74.17	76.97	31.20	23.01	33.09	268	214	41.92	82.90	1.10	49.60	3.02	146.30	68.70
7	58.72	49.58	70.23	78.74	93.99	82.16	58.01	265	216	36.92	88.60	4.30	46.68	4.90	106.66	25.60
8	55.99	49.74	65.37	71.13	64.04	56.31	42.09	267	216	36.02	75.30	3.12	47.62	6.66	108.28	35.68
9	53.46	50.15	62.43	65.60	35.55	29.77	32.20	269	216	37.82	66.30	1.46	49.56	6.80	124.86	58.34
10	55.05	45.31	85.34	94.64	103.82	87.79	83.27	268	216	34.64	117.60	0.64	42.52	2.90	118.26	21.48
11	51.47	45.37	85.33	91.30	66.69	54.71	57.96	268	215	35.44	109.10	2.46	43.78	3.22	123.54	31.16
12	48.86	45.70	83.53	86.90	37.94	28.35	43.37	270	215	36.68	100.40	1.66	45.26	3.68	139.08	51.36
13	56.01	45.14	75.22	85.55	114.94	97.43	76.04	267	215	33.28	101.40	4.94	41.52	3.40	109.04	20.80
14	50.13	44.29	74.95	80.69	64.20	52.39	48.88	269	215	34.72	90.20	1.68	42.66	3.06	113.52	31.66
15	47.95	45.01	74.98	78.03	34.08	26.39	36.24	269	215	36.18	85.00	1.22	44.84	3.80	134.82	56.06
16	55.36	44.78	70.20	80.18	110.72	94.65	68.70	267	215	33.04	91.50	4.40	41.34	3.56	104.42	21.44
17	51.16	44.30	64.90	71.32	72.28	61.53	45.96	270	215	33.44	76.00	2.68	42.16	3.96	102.72	29.66
18	48.50	45.19	64.83	68.05	36.20	29.72	33.39	270	216	35.04	69.80	1.06	44.76	4.76	122.68	53.88
19	49.77	40.54	79.75	88.71	99.75	82.90	78.99	267	215	30.72	105.70	0.52	38.04	2.78	112.46	21.80
20	46.70	40.62	79.94	85.97	67.53	54.23	56.38	269	215	31.86	99.40	0.36	39.20	2.66	115.18	28.06
21	43.47	39.91	79.92	83.71	42.59	31.91	43.24	270	215	32.22	94.60	0.32	39.44	2.58	129.72	45.38
22	51.62	40.83	69.71	80.01	114.52	96.94	76.77	267	215	29.92	91.00	0.32	37.42	3.08	103.82	21.48
23	45.98	39.68	69.29	75.39	68.29	56.38	49.53	269	215	30.82	81.60	0.02	37.92	2.58	104.10	27.48
24	43.68	40.95	67.68	70.71	34.20	24.49	35.75	271	216	32.86	74.10	0.60	40.00	2.50	125.92	53.96
25	49.24	40.36	63.57	71.90	93.30	79.62	57.14	269	215	30.02	77.70	0.28	37.62	3.14	97.62	23.48
26	45.95	39.91	61.81	67.53	64.02	54.09	42.38	268	215	30.84	69.70	0.28	38.36	2.92	99.28	30.16
27	43.36	40.45	61.03	64.06	34.04	26.02	31.51	269	214	32.38	64.00	0.38	40.14	3.04	118.44	53.54

**Table 2.40: RL40 test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.86	50.28	86.17	96.19	111.04	95.01	85.43	266	216	36.70	121.70	6.34	46.68	5.10	122.00	23.08
2	57.04	50.57	85.43	91.56	68.52	58.21	57.76	269	216	38.28	110.10	3.54	48.62	5.56	125.54	32.60
3	53.58	50.19	85.29	88.66	37.86	30.24	42.24	269	215	38.78	103.30	2.36	49.64	5.96	143.90	54.52
4	61.29	49.97	76.00	86.68	117.66	101.56	75.78	265	215	35.88	103.70	6.28	46.06	5.18	111.62	22.16
5	57.06	50.68	75.86	81.89	67.18	57.31	49.60	268	215	37.40	92.80	3.20	48.66	6.38	117.44	33.96
6	52.94	50.19	75.62	78.45	31.40	24.59	35.10	267	215	39.12	85.60	1.64	49.96	6.14	142.60	63.22
7	58.72	49.81	70.04	78.28	91.25	79.98	56.54	266	215	36.06	87.80	4.42	46.80	5.88	107.42	26.90
8	56.00	49.83	65.46	71.16	63.51	55.45	41.99	268	216	35.98	75.40	2.96	47.74	6.96	108.84	36.24
9	53.43	49.78	63.06	66.41	37.62	32.79	33.07	270	216	36.40	67.40	1.62	48.96	7.66	122.48	55.10
10	55.23	45.52	85.59	94.91	103.82	86.82	82.34	267	215	34.32	118.60	4.86	42.54	3.26	119.74	22.52
11	51.60	45.50	85.45	91.41	66.56	54.74	58.20	268	215	35.20	109.60	3.10	43.76	3.60	124.32	31.66
12	48.43	44.97	85.18	88.74	40.01	30.89	43.96	270	214	35.76	103.30	1.70	44.58	3.82	139.10	49.76
13	56.32	45.26	75.84	86.40	117.36	99.43	78.58	267	216	33.08	102.96	5.88	41.64	3.74	110.34	20.94
14	50.38	44.33	75.47	81.31	65.23	54.22	49.95	268	215	34.28	91.02	2.30	42.60	3.46	114.10	31.50
15	47.98	45.08	75.20	78.22	34.03	26.01	36.41	270	215	35.90	85.00	1.22	44.90	4.06	135.66	56.70
16	55.69	44.82	70.53	80.80	113.94	97.51	70.63	266	215	32.62	92.60	4.96	41.24	3.88	105.06	21.52
17	51.44	44.62	65.10	71.42	70.95	61.00	45.87	269	215	33.02	76.20	2.96	42.48	4.62	103.58	30.34
18	48.23	44.80	65.29	68.64	37.64	30.73	34.04	270	215	34.72	70.30	1.14	44.36	4.68	121.48	52.22
19	51.07	41.54	80.84	89.96	101.90	85.16	80.22	268	215	31.64	108.40	0.26	39.06	2.88	113.88	21.92
20	46.16	39.93	80.36	86.46	68.54	55.90	58.04	269	215	31.32	100.40	0.32	38.46	2.50	114.82	27.12
21	44.05	40.54	79.91	83.62	41.58	31.38	42.61	270	215	32.78	94.10	0.66	40.10	2.50	130.78	46.64
22	52.39	41.29	70.42	81.01	117.78	99.49	79.53	267	215	30.30	93.00	0.96	37.78	3.10	105.06	21.24
23	45.55	39.12	69.55	75.80	70.20	57.65	49.50	269	215	30.18	82.20	0.10	37.26	2.66	105.06	27.98
24	43.38	40.26	69.67	72.98	37.24	27.82	35.91	270	214	32.62	77.10	0.48	39.94	2.62	123.68	49.94
25	50.05	40.78	65.04	73.74	97.42	83.21	59.57	269	215	30.30	80.10	0.38	37.80	3.06	98.72	22.72
26	47.31	40.56	65.17	71.59	71.51	60.23	47.01	267	214	30.98	76.20	0.96	38.62	3.30	101.30	28.10
27	43.58	40.10	64.63	68.20	40.02	30.94	34.79	269	214	31.78	69.70	0.68	39.72	3.32	116.32	47.40

## 2.4 Refrigerant Overcharge

Adding refrigerant to the system simulated the refrigerant overcharge condition. The base refrigerant charge in the system was 300 pounds. Each fault level increased the refrigerant charge by 10% as shown in Table 2.41. These fault tests were a natural continuation of the refrigerant leak testing done earlier, with each successive test adding 30 pounds of refrigerant. The amount of refrigerant added was weighed on a laboratory scale with an uncertainty of  $\pm 0.1$  pounds.

**Table 2.41: Fault levels for refrigerant overcharge**

<b>Case</b>	<b>Desired Condition</b>	<b>Actual Charge</b>
<b>Normal Operation</b>	300 lbs refrigerant	300 lbs
<b>Fault Level 1</b>	10% increase in charge	330 lbs
<b>Fault Level 2</b>	20% increase in charge	360 lbs
<b>Fault Level 3</b>	30% increase in charge	390 lbs
<b>Fault Level 4</b>	40% increase in charge	420 lbs

The error in the actual charge is less than 1%. Each additional 30 pounds of refrigerant was added from a 30-pound net weight non-reusable canister. Thus the actual amount of refrigerant added was based on a moving reference point, with the final charge having an uncertainty equaling the accumulated uncertainty of the previous measurements ( $\pm 0.5$  pounds).

**Table 2.42: RO10 test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.39	50.70	85.61	94.83	102.44	87.11	81.95	267	216	36.96	127.00	10.98	47.30	5.42	126.36	24.86
2	56.08	49.67	85.61	91.70	68.55	57.40	60.04	270	215	37.22	115.90	8.02	47.74	5.66	129.72	33.68
3	53.64	50.35	85.83	89.16	37.49	29.52	43.69	270	215	38.80	107.40	5.20	49.76	6.10	147.42	56.14
4	60.53	50.26	75.83	85.51	107.10	92.66	72.39	266	217	35.88	109.00	11.16	46.72	5.96	116.12	23.66
5	56.69	50.45	76.22	82.14	66.06	56.05	51.00	268	216	36.98	97.80	7.34	48.46	6.54	121.94	35.70
6	52.70	49.86	76.10	78.99	32.18	25.45	36.20	267	215	38.40	88.90	4.52	49.52	6.22	144.06	62.84
7	58.59	49.29	71.04	79.74	96.47	83.68	62.30	266	216	36.02	97.20	10.26	46.28	5.36	111.42	25.42
8	56.26	49.84	66.30	72.29	67.07	57.80	45.11	269	216	36.52	82.10	7.68	47.72	6.38	111.48	34.28
9	53.70	49.79	64.38	68.05	41.36	35.20	35.22	271	216	36.64	73.00	5.18	48.88	7.38	123.28	51.94
10	55.18	46.30	85.10	93.70	96.26	79.67	79.19	269	215	34.92	124.00	10.52	43.56	3.68	124.76	25.04
11	51.06	44.89	85.94	91.98	67.71	55.42	61.58	269	216	34.44	116.30	7.90	43.12	3.68	129.18	33.00
12	48.94	45.42	85.43	89.04	40.44	31.45	45.27	269	215	35.98	107.90	5.62	44.98	4.06	142.48	50.66
13	56.78	46.26	75.97	86.06	112.10	94.44	78.49	267	215	33.96	110.90	11.62	42.86	4.06	115.24	22.02
14	51.95	45.03	76.37	83.11	75.20	61.89	56.43	268	215	34.32	101.00	8.58	43.06	3.84	116.80	28.72
15	48.39	45.41	75.79	78.79	33.70	26.65	37.32	270	215	36.02	89.30	4.72	45.26	4.30	138.70	57.22
16	55.13	45.29	69.77	79.01	102.80	88.21	67.08	267	215	32.94	97.00	10.78	41.94	4.24	109.08	23.14
17	51.11	44.45	66.32	72.46	70.06	59.65	47.48	274	215	33.12	82.50	7.86	42.44	4.56	108.36	31.16
18	48.45	44.97	66.39	69.87	39.22	31.21	35.57	270	215	34.94	75.70	5.22	44.48	4.48	124.32	51.30
19	51.20	42.10	81.02	89.71	97.11	81.62	77.17	268	215	32.16	115.80	10.64	39.88	2.98	119.74	23.92
20	46.65	40.42	81.13	87.26	68.85	55.94	58.58	269	215	32.10	106.20	7.04	39.36	2.62	121.04	29.92
21	44.26	40.77	80.87	84.60	42.04	31.29	44.32	270	215	32.84	99.60	5.40	40.24	2.68	134.40	47.20
22	51.96	41.00	70.64	81.06	115.34	98.40	77.71	266	215	30.72	100.50	10.70	38.30	3.04	108.68	20.80
23	46.33	39.70	71.19	77.47	70.45	59.37	52.26	270	215	30.72	90.10	7.62	38.20	2.94	110.38	28.28
24	43.53	40.27	71.21	74.62	38.18	29.19	37.73	269	215	32.36	82.30	4.56	39.90	2.84	126.62	49.62
25	51.03	40.67	67.73	77.38	107.32	92.88	69.17	267	215	30.48	93.40	10.00	38.04	3.16	105.06	21.30
26	46.71	39.86	65.82	72.36	73.17	61.49	49.12	268	215	30.96	81.20	6.94	38.42	3.04	104.22	27.78
27	43.39	39.86	65.10	68.72	40.61	31.63	36.02	269	215	31.78	73.40	4.78	39.36	2.94	117.92	46.54

Table 2.43: RO20 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.07	50.68	85.01	94.09	100.84	84.37	79.37	267	216	37.04	126.30	12.04	47.30	5.46	126.62	25.70
2	55.73	49.30	85.36	91.53	68.98	57.66	60.23	269	215	36.98	116.20	8.36	47.30	5.38	129.72	33.64
3	53.58	50.21	85.47	88.89	38.35	30.23	43.09	269	215	38.82	107.30	5.50	49.64	6.16	147.20	55.62
4	60.64	50.41	75.37	85.14	107.80	92.11	71.88	265	216	35.74	108.90	12.08	46.64	5.88	116.28	23.92
5	56.66	50.28	75.94	82.04	67.43	57.11	51.53	265	215	36.62	97.80	8.08	48.22	6.72	121.26	34.84
6	52.65	49.85	75.82	78.70	32.00	25.14	35.83	267	216	38.26	88.50	4.48	49.52	6.48	144.26	63.18
7	58.78	49.30	71.10	80.02	98.75	85.29	63.24	266	216	35.80	97.80	10.88	46.10	5.30	111.64	25.34
8	56.30	49.90	66.24	72.21	66.54	57.41	44.95	267	215	35.88	81.70	7.84	47.72	6.92	112.16	35.46
9	53.63	49.71	64.29	67.98	41.48	35.19	35.06	270	215	37.40	72.50	5.00	48.90	6.60	122.82	51.88
10	55.35	46.58	84.92	93.43	94.82	79.08	78.30	267	216	34.66	123.00	10.84	43.64	4.10	125.42	26.00
11	50.60	44.39	85.88	91.99	68.28	55.50	62.03	268	215	34.50	116.60	7.82	42.66	3.20	128.48	32.48
12	48.86	45.39	85.34	88.95	40.47	31.10	45.16	269	216	36.10	107.20	5.74	45.00	3.96	142.48	50.90
13	56.89	46.20	76.09	86.41	114.74	96.32	80.75	267	216	33.56	111.80	12.50	42.56	4.24	116.34	22.62
14	53.40	46.41	76.21	82.88	74.68	62.65	55.77	269	215	34.52	100.60	8.66	44.24	4.80	117.68	29.66
15	48.19	45.26	75.63	78.68	34.20	26.23	36.98	270	215	35.88	88.70	4.52	45.12	4.32	138.66	57.78
16	53.72	44.21	67.85	76.89	100.66	85.53	63.43	267	216	32.34	92.90	10.90	41.00	3.98	107.18	23.70
17	50.65	44.09	65.78	71.82	68.67	58.82	46.85	273	215	32.40	81.30	7.70	42.00	4.84	108.20	31.80
18	48.37	45.01	65.61	68.97	37.52	30.08	34.62	268	215	35.26	73.80	4.74	44.56	4.30	124.88	53.28
19	50.49	41.77	79.74	88.16	94.29	78.06	74.01	269	215	31.02	112.10	10.24	39.14	3.70	118.80	25.04
20	47.00	40.95	80.57	86.55	67.04	54.24	57.53	269	215	32.48	106.20	8.00	39.82	2.58	122.00	30.86
21	43.72	40.25	80.10	83.83	42.01	31.11	43.68	270	215	32.82	98.20	5.36	39.98	2.46	133.62	47.08
22	52.00	41.36	69.95	80.18	113.42	95.62	75.35	266	216	30.36	100.20	11.80	38.26	3.44	109.12	21.52
23	45.63	39.31	69.65	75.84	69.70	56.46	50.40	270	215	30.26	87.90	8.02	37.82	3.16	109.80	29.10
24	43.34	40.15	69.87	73.22	37.76	28.60	37.05	270	215	32.16	80.60	5.08	39.78	3.04	126.40	50.22
25	49.28	40.42	63.99	72.36	93.38	79.37	58.32	268	215	30.04	85.10	10.24	37.86	3.40	102.76	23.86
26	47.07	40.50	64.81	71.12	70.28	58.92	47.47	268	215	30.56	80.40	8.04	38.74	3.56	105.38	29.44
27	43.70	40.18	65.48	69.11	40.67	31.48	36.27	269	215	32.32	74.60	5.26	39.82	2.80	118.84	46.58

Table 2.44: RO30 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	61.76	53.03	84.80	93.69	99.09	78.52	79.05	267	216	38.34	134.20	17.20	50.06	6.84	135.12	30.36
2	57.01	50.82	85.38	91.84	72.53	55.75	62.02	269	216	37.72	123.40	13.22	48.84	6.20	136.56	36.76
3	53.80	50.44	85.46	89.10	40.98	30.17	44.37	270	215	38.64	111.90	8.16	49.88	6.48	151.14	57.20
4	60.78	50.62	75.44	85.83	114.34	90.90	77.51	264	215	35.64	119.60	18.56	46.92	6.20	123.18	25.34
5	56.60	50.47	75.68	81.91	69.17	55.00	52.11	266	216	36.90	102.10	11.24	48.42	6.66	125.12	36.34
6	52.55	49.75	75.74	78.72	33.20	25.09	36.38	267	215	38.76	90.46	5.66	49.52	5.98	145.92	63.68
7	58.64	49.68	70.09	78.93	97.83	80.51	61.69	266	216	35.80	101.00	14.66	46.68	5.92	114.74	26.72
8	56.21	50.02	65.78	71.78	67.01	55.47	44.78	268	215	35.72	83.80	10.36	47.88	7.16	115.06	36.86
9	53.44	49.77	63.20	66.83	40.77	32.90	34.36	270	215	36.36	72.80	6.32	48.94	7.70	125.70	54.92
10	53.56	45.39	81.33	89.60	92.55	73.22	70.67	269	215	34.62	119.40	13.46	42.96	3.36	123.58	25.88
11	50.43	44.28	85.43	91.83	71.38	55.02	63.37	268	215	34.46	120.10	10.82	42.56	3.36	131.08	33.02
12	49.31	45.74	85.47	89.32	43.22	31.85	46.66	270	215	35.86	111.00	7.40	45.22	4.42	144.62	51.34
13	57.22	47.17	75.88	86.12	113.78	90.28	79.57	267	216	34.30	118.10	17.08	43.74	4.52	120.94	23.88
14	52.43	45.81	75.95	82.67	75.16	59.38	55.83	269	215	34.48	103.06	11.10	43.84	4.50	120.40	31.22
15	48.27	45.29	75.83	78.97	35.38	26.65	37.74	270	215	35.64	90.56	5.76	45.10	4.46	140.24	57.76
16	55.45	45.62	70.30	80.13	109.06	88.41	70.23	266	216	33.02	104.60	15.82	42.24	4.44	113.32	23.08
17	50.87	44.08	66.58	73.23	75.80	60.90	49.69	273	215	32.56	86.50	10.86	41.96	4.68	110.26	30.44
18	48.55	45.03	66.67	70.33	41.06	31.55	36.14	269	215	35.24	77.30	6.12	44.50	4.26	125.44	51.40
19	51.34	42.67	80.44	89.14	97.01	77.79	75.60	268	215	32.48	118.20	13.30	40.32	3.06	122.58	25.58
20	46.28	40.01	81.15	87.43	70.33	56.11	59.93	269	215	31.34	108.60	8.74	38.78	2.90	122.78	30.72
21	43.56	39.97	80.93	84.73	42.79	32.11	44.84	270	214	32.96	100.20	5.82	39.84	2.18	133.74	45.98
22	51.59	41.00	69.99	80.24	113.62	94.87	75.00	266	215	30.60	101.00	12.72	38.32	3.24	109.62	21.52
23	45.68	39.38	69.87	76.02	68.94	56.39	50.45	269	215	30.60	88.40	8.42	38.08	3.04	110.06	29.04
24	43.03	39.91	69.85	73.19	37.50	28.02	36.77	270	215	32.38	80.30	5.06	39.72	2.66	126.12	50.38
25	49.71	40.95	64.17	72.74	95.48	78.67	58.83	268	216	30.24	87.40	12.32	38.36	3.46	104.66	24.38
26	47.10	40.60	64.90	71.26	71.22	58.08	47.63	268	215	30.94	81.20	8.96	38.94	3.42	106.06	29.64
27	43.50	40.09	64.59	68.17	39.86	30.50	35.39	268	214	32.16	72.70	4.98	39.66	3.10	118.86	47.88

Table 2.45: RO40 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	61.45	52.97	85.30	94.03	97.11	76.12	78.01	267	215	38.40	134.90	17.12	50.08	6.80	136.26	31.28
2	55.68	49.17	85.96	92.92	77.67	58.25	66.24	268	215	37.10	128.02	14.14	47.20	5.18	136.20	34.38
3	53.90	50.49	85.97	89.78	42.69	30.59	45.37	269	215	38.88	114.00	8.92	49.80	6.04	151.46	56.82
4	61.21	51.09	75.84	86.46	116.72	90.73	80.04	264	215	35.92	123.50	20.38	47.30	6.38	126.02	26.18
5	56.52	50.20	76.14	82.80	73.83	56.44	54.62	266	214	36.98	106.80	13.64	48.14	6.34	126.84	35.40
6	52.81	50.05	75.82	78.96	34.96	24.74	36.75	267	215	38.46	93.00	7.26	49.66	6.36	147.96	64.32
7	58.37	49.05	70.59	80.35	108.22	83.82	67.44	266	216	35.46	109.40	18.44	45.80	5.28	118.18	25.62
8	56.23	49.97	65.89	72.28	71.39	56.15	46.75	268	215	35.56	88.30	13.20	47.78	7.18	117.68	36.70
9	53.37	49.90	63.07	66.74	41.29	31.17	34.17	270	216	37.94	74.30	7.76	49.22	6.36	128.70	56.82
10	55.32	48.02	84.70	92.43	86.67	65.60	72.85	269	216	35.82	128.90	15.70	45.70	4.94	134.64	32.44
11	51.43	45.40	85.51	92.09	73.81	53.91	65.66	269	215	34.66	125.20	13.76	43.74	4.22	137.22	36.72
12	48.44	44.91	85.28	89.31	45.14	31.58	47.60	268	215	35.60	113.30	9.26	44.46	3.86	146.90	52.26
13	56.33	46.93	74.85	84.71	110.62	84.50	76.51	269	216	33.94	118.80	19.04	43.72	4.82	122.82	20.28
14	51.79	45.19	75.84	82.85	78.42	59.17	58.21	268	215	34.04	108.40	14.08	43.20	4.18	123.76	31.80
15	48.10	45.15	75.81	79.15	37.56	26.43	38.37	269	215	35.38	93.60	7.50	44.84	4.50	141.86	57.92
16	56.14	46.25	70.73	81.08	114.78	88.64	75.48	266	215	32.82	113.00	19.74	42.70	5.16	118.86	24.50
17	51.32	44.68	66.59	73.44	77.97	59.64	50.66	273	216	33.48	91.10	13.80	42.70	4.32	114.12	31.52
18	48.42	44.84	66.76	70.77	44.94	31.95	37.16	268	215	35.10	81.30	8.60	44.34	4.28	126.98	50.52
19	51.05	43.30	80.64	88.91	92.35	69.60	73.08	268	216	33.44	122.70	16.26	41.40	3.10	128.08	28.92
20	46.23	39.81	81.21	87.97	75.58	57.40	63.07	269	215	31.60	113.70	11.66	38.78	2.60	125.58	30.86
21	43.57	40.02	80.94	84.77	42.96	31.64	44.77	269	214	32.74	100.50	5.96	39.84	2.40	134.10	46.10
22	53.44	43.72	70.37	80.61	113.32	87.34	74.94	266	216	31.92	111.10	19.44	40.64	4.08	117.64	24.10
23	46.67	40.19	71.23	77.92	74.87	57.86	53.60	269	214	31.64	94.90	11.10	38.98	2.72	114.04	29.38
24	43.21	39.99	71.19	74.62	38.67	28.75	37.66	271	214	33.00	82.90	5.40	39.92	2.30	126.66	49.12
25	50.98	41.98	66.37	75.70	103.96	80.82	65.16	268	216	30.60	100.70	18.26	39.18	4.08	112.16	24.28
26	47.39	40.57	66.24	73.40	79.81	61.17	52.29	267	215	31.34	90.38	13.42	39.10	3.08	110.62	28.56
27	43.59	39.90	66.35	70.47	46.01	33.00	38.02	268	215	31.98	79.30	7.42	39.40	2.78	120.52	45.50

## 2.5 Excess Oil

Adding oil to the system simulated the excess oil condition. The base oil charge in the system was 22 pounds. Each fault level increased the oil charge by varying amounts as shown in Table 2.46. The amount of oil added was weighed on a laboratory scale with an uncertainty of  $\pm 0.1$  pounds.

**Table 2.46: Fault levels for excess oil**

<b>Case</b>	<b>Desired Condition</b>	<b>Actual Charge</b>
<b>Normal Operation</b>	22 lbs oil (2.75 gallons)	22 lbs
<b>Fault Level 1</b>	14% increase in charge	25 lbs
<b>Fault Level 2</b>	32% increase in charge	29 lbs
<b>Fault Level 3</b>	50% increase in charge	33 lbs
<b>Fault Level 4</b>	68% increase in charge	37 lbs

The base oil charge of 22 pounds is based on specifications provided by the chiller manufacturer. In an attempt to determine the actual oil charge, about 13 pounds of oil was recovered (the rest presumably was trapped in various locations, some could be seen through the sight glass near one of the oil pumping reservoirs). The remaining trapped oil was assumed to be approximately 9 pounds—this could not be experimentally verified, since the only way to remove all the oil would have been to dismantle the compressor. Hence the uncertainty in the base oil charge is unknown (theoretically could be as high as  $\pm 5$  pounds), but the amount of excess oil charged into the system is known to within an error of less than 2%.

**Table 2.47: EO14 test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	61.07	51.20	85.53	94.87	103.78	88.81	80.61	266	216	37.90	125.30	10.42	47.82	5.00	124.12	23.74
2	55.58	49.17	85.49	91.62	68.68	57.59	59.58	269	216	37.38	113.60	6.70	47.20	4.96	127.78	33.00
3	54.02	50.74	85.60	88.91	37.07	29.38	43.48	268	215	39.42	105.50	4.46	50.18	6.00	146.48	56.00
4	60.75	50.54	75.82	85.46	106.12	91.90	71.07	264	216	36.26	106.50	9.92	46.88	5.64	114.74	23.66
5	56.35	50.00	76.11	82.15	67.12	57.02	50.97	267	216	37.22	95.90	6.20	47.90	5.64	119.04	33.90
6	53.10	50.33	75.83	78.60	30.79	24.79	35.46	266	215	38.96	87.10	3.46	50.04	6.30	144.48	64.46
7	58.04	49.50	68.97	76.92	88.10	76.84	55.63	266	216	35.64	89.10	7.78	46.56	5.92	109.20	27.78
8	56.02	49.84	65.57	71.26	63.44	55.45	42.99	268	215	35.84	78.14	5.72	47.76	6.94	110.70	36.24
9	53.52	49.83	63.24	66.61	37.99	32.98	33.68	270	215	36.62	69.30	3.94	48.98	7.44	122.98	54.42
10	55.55	46.38	85.02	93.76	97.54	82.25	79.33	268	215	34.86	121.60	9.16	43.52	3.80	122.92	24.16
11	50.85	44.69	85.33	91.34	67.20	55.10	60.04	268	215	34.62	112.70	6.38	43.04	3.54	126.30	32.06
12	48.93	45.45	85.09	88.65	40.08	31.06	44.60	270	214	36.32	105.00	4.42	44.98	3.66	140.40	50.10
13	56.86	46.09	75.88	86.10	113.72	96.65	79.19	267	215	33.60	108.40	9.96	42.46	4.00	113.70	21.68
14	51.73	44.80	76.18	82.81	74.08	62.31	55.46	268	215	34.26	97.30	6.46	42.82	3.68	114.82	28.66
15	47.83	44.88	75.80	78.80	33.61	26.45	37.36	269	215	35.44	87.20	3.54	44.60	4.12	136.56	56.16
16	54.98	45.02	69.93	79.26	103.62	89.12	66.28	267	215	32.90	94.10	8.40	41.66	4.04	107.14	22.86
17	51.59	45.09	66.41	72.49	68.67	58.46	46.18	271	216	33.54	80.00	5.84	43.00	4.66	107.38	31.56
18	48.54	45.07	66.41	69.85	38.62	31.03	34.98	270	215	34.52	73.60	3.64	44.56	5.08	123.42	56.94
19	49.49	40.63	80.31	88.86	95.25	79.33	72.98	268	215	31.68	110.20	8.10	38.70	2.44	115.82	22.74
20	47.06	40.94	81.09	87.11	67.35	54.83	57.63	269	215	32.10	104.50	5.92	39.72	3.02	120.52	30.32
21	44.49	41.01	80.90	84.61	41.73	31.16	44.31	270	215	33.10	97.90	4.42	40.50	2.68	133.26	46.78
22	51.71	40.88	70.50	80.77	113.64	97.01	75.52	265	215	30.76	98.10	9.10	38.06	2.84	107.10	20.64
23	46.39	39.80	71.14	77.40	70.14	58.95	51.49	269	215	31.14	88.00	6.04	38.42	2.94	109.00	28.28
24	43.47	40.25	71.10	74.45	37.51	28.99	37.32	270	216	32.40	80.90	3.68	39.98	2.82	125.48	49.36
25	50.76	41.13	66.67	75.77	101.20	86.52	63.38	267	215	30.68	87.90	8.08	38.54	3.30	102.96	22.32
26	46.66	40.02	65.09	71.42	70.72	59.43	47.30	268	215	31.44	78.70	6.12	38.66	2.52	103.30	28.36
27	43.73	40.24	64.86	68.41	39.96	31.21	35.39	270	215	31.94	71.70	3.86	39.78	3.20	117.38	47.04

Table 2.48: EO32 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.96	51.30	85.82	94.99	101.88	87.05	80.82	267	216	37.56	125.60	10.44	47.82	5.32	125.08	24.46
2	55.98	49.54	85.67	91.81	68.76	57.86	60.10	269	216	37.54	114.20	6.74	47.58	5.02	128.26	33.42
3	53.82	50.45	85.98	89.35	37.80	30.23	43.72	270	215	39.14	106.50	4.54	49.96	6.02	146.16	55.18
4	60.74	50.45	76.00	85.76	108.24	92.65	72.80	266	216	36.06	107.10	10.22	46.80	5.84	115.14	23.74
5	56.49	50.10	76.32	82.47	68.58	57.49	51.80	268	216	37.36	96.90	6.42	48.00	5.72	119.20	33.56
6	53.30	50.55	76.04	78.82	31.08	24.66	35.76	268	215	39.56	87.00	3.32	50.22	5.78	144.32	64.42
7	59.19	49.43	72.03	81.25	102.38	87.48	65.58	267	215	35.64	98.00	8.70	45.98	5.44	111.18	25.00
8	56.57	50.24	66.42	72.27	65.51	56.95	44.47	269	216	36.52	79.80	5.88	48.08	6.68	111.10	35.48
9	54.10	49.98	65.38	69.16	42.75	37.03	36.34	271	216	36.82	73.20	4.16	48.92	7.16	120.82	49.34
10	55.98	46.73	85.61	94.43	98.94	82.87	81.15	269	215	35.20	123.10	9.48	43.94	3.72	123.88	24.44
11	50.93	44.58	86.09	92.21	68.84	57.07	62.02	270	216	34.80	114.68	6.52	42.98	3.24	126.80	31.44
12	49.03	45.46	85.84	89.47	40.84	31.97	46.20	270	215	35.84	106.70	4.58	44.90	4.10	140.88	49.76
13	56.82	45.97	76.20	86.57	115.44	97.38	80.73	267	215	33.56	109.10	10.18	42.40	4.00	114.18	21.76
14	52.74	45.82	76.13	82.74	74.23	62.10	55.49	270	215	34.32	97.40	6.64	43.72	4.44	115.76	29.76
15	48.29	45.35	75.50	78.53	34.01	26.39	37.39	270	216	36.18	86.90	3.50	45.22	4.06	136.98	57.12
16	53.37	43.92	67.67	76.51	99.30	84.60	61.66	270	215	32.76	88.58	7.64	41.08	3.70	105.06	23.96
17	51.50	45.12	65.91	71.78	66.61	57.26	45.86	272	215	33.44	79.00	5.62	43.08	4.84	107.38	32.30
18	48.47	45.07	65.65	68.98	37.49	30.50	34.93	271	215	34.94	72.70	3.56	44.56	4.50	123.44	52.30
19	49.08	40.01	79.78	88.38	96.60	81.53	73.13	270	216	31.94	109.50	8.30	38.20	1.54	114.32	21.80
20	46.74	40.55	80.66	86.72	68.25	55.47	57.50	270	215	32.86	103.90	6.24	39.74	2.22	119.26	29.58
21	43.99	40.46	80.43	84.16	42.29	31.63	44.33	271	215	33.08	97.30	4.24	40.18	2.44	132.06	46.12
22	51.01	40.54	69.54	79.32	108.98	93.75	71.47	268	215	30.80	94.60	8.74	38.00	2.68	105.54	20.96
23	45.99	39.58	69.85	75.99	69.37	57.30	50.28	271	215	31.20	85.70	6.30	38.42	2.64	108.16	28.68
24	43.45	40.36	69.80	73.08	36.98	27.74	36.66	271	215	32.84	78.42	3.42	40.12	2.66	125.28	50.74
25	49.71	40.27	65.14	73.91	98.53	84.64	61.62	270	215	30.46	85.00	8.12	37.88	2.96	101.54	22.62
26	46.87	40.30	64.89	71.22	70.99	58.98	47.27	269	215	31.80	78.24	6.22	39.02	2.62	103.38	28.66
27	43.79	40.34	64.63	68.19	40.24	30.87	35.62	271	215	32.28	71.30	3.74	39.88	2.96	117.48	47.34

Table 2.49: EO50 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.70	51.14	85.15	94.18	100.29	85.96	79.25	267	216	37.78	123.60	10.14	47.82	5.28	124.02	24.48
2	55.97	49.57	85.43	91.53	68.61	57.55	60.32	270	216	37.62	113.50	6.86	47.64	5.20	128.08	33.36
3	53.73	50.38	85.73	89.10	37.95	30.09	44.12	270	216	39.04	106.30	4.48	49.84	5.96	145.98	54.92
4	60.35	50.45	75.31	84.59	103.48	89.05	69.86	267	216	36.22	104.30	9.60	46.84	5.66	114.38	24.42
5	56.19	49.87	75.89	81.93	67.51	56.79	51.72	269	216	37.54	95.50	6.20	47.86	5.48	119.00	34.04
6	53.13	50.35	75.89	78.72	31.59	24.88	36.74	268	215	39.08	87.60	3.74	50.06	6.16	143.92	63.30
7	58.33	49.68	69.59	77.58	89.62	77.72	57.73	269	216	36.26	90.18	7.52	46.68	5.64	109.44	27.56
8	55.99	49.76	65.82	71.48	63.86	56.02	44.31	271	216	35.84	78.42	5.82	47.62	6.82	110.94	36.30
9	53.57	49.84	63.30	66.76	39.17	33.40	34.87	272	215	36.68	69.40	3.94	49.00	7.36	122.82	54.14
10	55.10	46.18	84.62	93.06	94.56	80.24	77.39	269	216	34.96	120.00	8.92	43.40	3.42	121.86	23.90
11	51.12	44.76	85.65	91.73	68.25	57.28	62.58	269	216	34.44	113.90	6.68	42.98	3.74	126.68	31.76
12	48.95	45.37	85.38	89.01	41.01	32.09	46.46	271	215	36.02	106.00	4.50	44.88	4.08	140.32	49.70
13	55.97	45.55	75.69	85.55	110.18	93.94	76.52	268	216	33.82	106.10	9.20	42.40	3.58	112.52	21.48
14	51.76	44.80	76.22	82.89	74.91	62.48	56.79	270	215	34.36	98.20	6.48	42.86	3.60	114.94	28.30
15	48.25	45.25	75.87	78.94	34.61	26.95	38.36	271	215	35.86	87.60	3.52	45.10	4.30	136.98	56.58
16	54.59	44.85	69.38	78.50	102.56	87.46	65.41	270	216	33.02	92.60	8.42	41.70	3.94	106.86	23.28
17	51.55	45.16	65.97	71.86	66.72	57.48	46.38	272	216	33.84	79.00	5.78	43.16	4.42	107.38	32.20
18	48.50	45.10	65.86	69.20	37.68	30.40	35.72	270	215	35.30	73.00	3.50	44.68	4.46	123.44	52.42
19	49.72	40.77	79.93	88.43	95.48	80.45	74.27	270	216	31.98	109.90	8.14	38.98	2.50	115.40	22.50
20	46.79	40.58	80.81	86.90	68.51	55.70	58.38	270	215	32.86	104.50	6.60	39.80	2.20	119.52	29.44
21	43.60	40.10	80.28	84.01	42.04	31.23	44.30	271	214	33.12	96.30	3.70	39.94	2.04	131.52	46.00
22	50.81	40.50	69.52	79.21	108.56	92.79	71.37	269	216	30.84	94.50	8.52	37.92	2.70	105.50	21.22
23	46.02	39.68	69.82	75.91	68.64	56.62	50.41	270	214	31.64	85.50	6.28	38.54	2.36	108.20	28.98
24	43.09	39.90	70.01	73.40	38.35	28.51	37.94	271	214	32.52	79.40	3.80	39.80	2.56	124.38	49.08
25	49.48	40.46	64.68	73.13	95.05	81.12	60.04	270	216	30.46	83.10	7.60	38.16	3.10	101.62	23.92
26	46.80	40.17	64.87	71.21	71.30	59.23	48.31	270	215	30.78	78.24	5.80	38.54	3.28	103.70	29.14
27	43.83	40.42	64.74	68.30	40.08	30.60	36.27	270	215	32.78	71.70	4.04	40.12	2.72	117.56	47.02

**Table 2.50: EO68 test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	64.03	57.10	82.80	89.24	70.52	62.14	59.77	263	215	41.16	111.50	8.38	54.14	8.12	128.80	35.02
2	56.11	49.95	85.42	91.56	67.28	55.35	60.46	263	216	37.74	114.00	7.42	47.76	5.14	129.42	34.66
3	53.45	50.15	85.65	89.11	37.94	29.55	44.72	263	215	38.68	106.90	4.98	49.36	5.82	147.24	56.16
4	59.97	51.12	74.99	83.48	92.23	79.37	65.05	261	215	35.96	102.18	9.72	47.38	6.52	115.80	26.92
5	56.91	50.73	76.02	81.99	66.08	55.44	52.11	266	215	36.90	96.10	6.80	48.24	6.46	120.86	35.60
6	53.51	50.80	75.85	78.68	31.47	24.29	37.15	266	215	38.38	87.40	3.88	50.22	6.98	145.72	65.16
7	59.18	50.49	69.91	78.02	89.74	77.87	59.18	266	215	36.04	91.50	8.16	46.92	5.90	110.70	28.12
8	55.93	50.00	65.49	71.06	62.30	53.15	43.76	268	215	36.60	77.80	5.82	47.74	6.30	111.32	37.14
9	53.40	49.99	63.02	66.32	37.02	30.51	34.45	269	215	37.02	68.90	3.72	49.02	7.10	125.22	56.84
10	55.24	48.16	83.80	90.63	74.83	63.40	64.98	263	215	35.92	113.78	8.36	45.74	4.82	124.66	29.78
11	51.13	45.07	85.38	91.47	66.91	54.18	61.42	264	214	34.90	113.40	6.70	43.36	3.42	127.56	32.94
12	48.66	45.24	85.20	88.85	40.13	30.60	46.50	264	215	35.76	105.40	4.48	44.72	3.92	141.46	50.98
13	54.64	45.83	72.06	80.44	93.82	79.06	63.80	269	215	33.70	95.60	8.34	42.74	4.24	110.38	25.12
14	51.63	44.92	75.52	81.96	72.12	60.03	55.80	269	215	33.70	96.20	6.70	42.74	4.22	115.64	30.26
15	47.99	45.16	75.23	78.28	34.38	25.31	38.44	270	215	36.32	86.60	3.80	44.92	3.66	137.10	56.76
16	53.77	45.81	66.01	73.44	83.38	71.29	54.59	269	215	33.48	83.20	7.44	42.96	4.62	105.78	27.92
17	51.73	45.67	65.47	71.15	64.25	54.26	45.40	271	215	33.78	77.50	5.60	43.68	4.96	108.72	34.56
18	48.36	45.11	65.33	68.64	37.16	29.03	35.54	270	214	34.76	72.30	3.62	44.56	4.76	124.28	53.78
19	48.66	40.99	78.02	85.34	82.32	68.55	65.12	270	215	32.56	103.16	7.14	38.66	1.36	114.26	24.82
20	46.39	40.17	80.39	86.49	68.52	55.47	60.03	269	214	32.74	103.80	6.24	38.54	1.02	118.22	28.54
21	44.22	40.81	80.15	83.89	42.16	30.44	45.03	270	214	33.42	96.90	4.36	40.48	2.28	132.90	47.02
22	50.75	41.65	68.34	76.85	95.37	81.41	63.94	269	215	31.46	89.96	7.96	39.18	3.10	105.10	23.34
23	45.56	39.24	69.61	75.77	69.37	56.65	51.44	270	215	31.34	85.20	6.18	37.76	1.84	107.62	28.62
24	43.47	40.38	69.78	73.07	37.11	27.61	37.93	271	214	33.00	78.62	3.60	40.28	2.48	125.74	56.02
25	49.95	41.07	64.67	72.96	93.40	79.39	60.03	271	215	30.76	83.10	7.60	38.62	3.32	101.98	24.26
26	46.70	40.24	64.67	70.91	69.73	57.86	48.02	268	215	31.06	77.80	5.94	38.70	3.18	103.86	29.56
27	43.40	39.93	64.63	68.26	40.58	31.08	36.84	269	214	32.10	71.90	4.04	39.64	2.90	117.64	47.06

Table 2.51: EO73 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	62.80	56.07	79.72	85.82	68.27	60.33	56.51	268	215	40.50	105.12	8.06	53.32	8.04	125.58	35.28
2	57.08	51.11	85.31	91.15	65.30	53.70	59.90	268	216	38.54	113.40	7.20	49.02	5.56	130.28	35.68
3	53.29	50.01	85.67	89.07	38.10	29.51	45.35	269	216	39.28	106.60	4.94	49.40	5.30	145.72	54.46
4	60.99	52.00	74.07	82.44	92.82	81.20	64.75	266	217	35.46	100.90	10.00	48.06	7.58	116.02	27.74
5	57.20	51.06	75.97	81.89	65.82	55.00	53.21	267	215	36.10	96.20	7.14	48.42	7.30	122.12	36.46
6	53.37	50.68	75.84	78.67	31.43	24.28	37.45	266	216	38.70	87.40	3.50	50.22	6.68	145.42	65.00
7	59.05	50.17	70.33	78.66	92.12	79.48	61.15	266	215	35.88	93.10	8.70	46.80	6.00	110.98	27.36
8	56.28	49.92	66.31	72.28	66.64	56.94	46.48	268	215	36.06	79.70	6.32	47.42	6.46	111.10	35.42
9	53.77	49.70	65.00	68.87	43.50	36.46	37.65	270	215	36.08	73.00	4.34	48.40	7.34	122.16	50.84
10	59.14	51.44	83.87	91.04	80.31	69.17	67.28	269	216	36.58	115.64	8.56	48.24	6.80	125.86	30.04
11	51.74	45.68	86.03	92.02	67.17	54.44	62.56	269	215	35.22	114.40	6.82	43.90	3.70	128.32	33.26
12	48.90	45.39	85.69	89.33	40.89	31.35	47.52	269	215	36.04	106.30	4.78	44.86	3.88	141.70	50.50
13	57.89	48.59	75.32	84.20	98.67	83.67	69.47	267	216	35.16	103.90	9.36	45.08	4.86	114.32	24.82
14	52.44	45.86	76.20	82.61	71.91	58.91	55.77	269	215	35.14	97.40	6.54	43.88	3.78	116.58	30.40
15	48.15	45.23	75.83	78.87	34.08	26.18	39.20	269	215	35.32	87.80	3.72	44.88	4.68	137.96	57.40
16	55.64	46.23	69.93	78.75	97.90	84.66	65.50	267	216	33.64	93.70	8.80	42.98	4.42	108.56	24.52
17	51.35	44.88	66.45	72.63	69.71	58.03	48.17	271	215	33.96	80.50	6.00	42.92	3.98	107.76	31.84
18	48.41	44.97	66.56	70.09	39.44	30.66	36.96	268	215	35.36	74.40	3.96	44.44	4.06	123.94	51.80
19	53.00	44.98	80.22	87.95	86.61	72.04	67.38	269	216	34.18	108.80	7.78	42.68	3.56	117.60	25.32
20	47.01	41.05	81.02	86.96	66.51	53.57	58.60	269	216	32.64	104.40	6.06	40.00	2.66	121.04	31.12
21	44.48	41.00	81.01	84.81	42.67	31.16	46.19	270	215	33.56	98.50	4.28	40.78	2.38	133.56	46.78
22	53.46	44.17	69.46	78.23	97.64	83.42	65.18	267	215	32.40	92.60	8.42	41.08	4.02	107.42	23.94
23	45.66	39.27	70.17	76.35	69.48	57.12	52.26	270	215	31.06	86.30	6.12	37.98	2.34	108.52	28.80
24	44.10	41.03	70.04	73.32	36.99	27.61	38.32	270	216	33.16	79.10	3.64	40.66	2.64	127.22	52.10
25	49.91	41.03	64.48	72.82	93.26	79.63	59.98	268	215	30.76	83.10	7.54	38.60	3.30	102.02	24.32
26	46.85	40.30	64.95	71.29	70.91	58.98	49.16	268	216	31.22	78.42	5.98	38.82	3.06	104.22	29.32
27	44.07	40.72	64.67	68.17	39.21	30.01	36.79	269	215	32.96	71.40	3.88	40.40	2.72	119.44	49.10

## 2.6 Condenser Fouling

Tubes were plugged in the condenser to simulate condenser fouling. The condenser contains 164 tubes; approximately half are used in the first pass and the remaining tubes for the second pass. Each fault level reduced the number of available tubes as shown in Table 2.52. The blocked tubes were evenly distributed between the two passes in a spread-out pattern.

**Table 2.52: Fault levels for condenser fouling**

<b>Case</b>	<b>Desired Condition</b>	<b>Actual Condition</b>
<b>Normal Operation</b>	164 unblocked tubes	No blocked tubes
<b>Fault Level 1</b>	12% reduction in tubes	20 blocked tubes
<b>Fault Level 2</b>	20% reduction in tubes	33 blocked tubes
<b>Fault Level 3</b>	30% reduction in tubes	49 blocked tubes
<b>Fault Level 4</b>	45% reduction in tubes	74 blocked tubes

There was an additional test run at a fault level with only a 6% reduction in tubes which was labeled CF6 and was performed before the other fault tests.

**Table 2.53: CF6 test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	61.22	51.49	85.78	95.07	102.52	87.39	82.91	265	216	37.22	127.18	10.84	47.46	5.40	126.48	25.14
2	55.65	49.31	85.49	91.61	68.37	56.68	59.52	268	215	36.82	115.16	7.44	47.00	5.36	129.06	33.60
3	53.78	50.47	85.66	89.00	37.40	29.78	42.77	268	216	38.54	106.60	4.96	49.68	6.44	147.36	56.04
4	60.68	50.41	75.82	85.57	107.38	92.27	72.85	264	216	35.22	108.20	10.86	46.14	5.96	115.80	23.82
5	56.59	50.30	76.20	82.21	66.38	56.38	50.92	265	215	36.30	96.90	6.82	47.84	6.68	120.78	34.84
6	52.91	50.16	75.99	78.80	31.18	24.63	35.54	267	215	38.62	87.60	3.78	49.76	6.26	143.98	63.18
7	58.84	49.63	70.98	79.66	95.80	82.80	61.41	265	216	35.00	95.50	9.10	45.98	5.86	110.94	26.00
8	56.65	50.45	66.31	72.04	63.81	55.71	43.69	268	215	35.18	79.60	6.04	47.84	7.68	112.04	36.54
9	53.79	49.77	64.80	68.63	42.79	36.05	35.45	269	215	36.10	72.70	4.30	48.50	7.46	121.32	50.50
10	56.08	47.07	85.35	94.04	96.94	80.86	79.21	268	215	34.80	123.40	9.90	43.88	4.20	125.16	25.48
11	50.57	44.30	86.09	92.27	68.98	56.24	62.01	268	215	34.20	115.42	6.92	42.52	3.30	127.28	31.58
12	49.31	45.92	85.39	88.95	39.77	30.35	45.06	268	215	35.92	106.30	4.54	45.22	4.42	142.30	51.46
13	56.92	46.26	76.18	86.45	113.70	95.60	81.33	266	215	32.74	110.60	11.30	42.06	4.58	116.08	22.76
14	52.36	45.51	76.22	82.83	73.74	61.25	55.27	268	215	33.92	98.60	6.90	43.18	4.42	116.08	29.40
15	48.00	45.13	75.84	78.86	33.72	25.62	37.11	268	215	36.12	87.20	3.78	44.86	3.68	136.80	56.40
16	54.61	44.38	70.15	79.85	107.50	91.92	68.36	266	216	32.62	96.50	8.96	41.08	3.70	107.56	21.74
17	51.53	45.02	66.47	72.63	69.38	58.12	46.55	271	215	33.12	80.60	6.08	42.78	4.74	107.68	31.64
18	48.59	45.18	66.53	69.96	38.45	30.53	34.88	269	215	35.02	73.90	3.82	44.58	4.58	123.82	51.88
19	49.57	40.62	80.76	89.40	96.24	80.19	76.23	267	215	31.10	112.20	7.84	38.36	2.66	117.76	23.76
20	46.85	40.73	81.14	87.19	67.74	54.77	57.76	269	215	32.16	105.20	6.22	39.64	2.74	120.62	30.16
21	44.06	40.54	80.92	84.71	42.52	31.51	44.35	269	214	33.10	98.50	4.42	40.14	2.24	132.80	46.20
22	51.73	40.81	70.66	81.13	115.62	98.04	77.71	265	216	30.48	99.20	9.32	37.18	2.22	107.86	20.74
23	45.95	39.32	71.22	77.62	71.65	59.35	52.08	269	215	31.14	88.80	6.26	37.70	2.10	108.84	27.58
24	43.59	40.37	71.39	74.82	38.51	28.63	37.48	269	214	33.06	81.30	3.84	40.18	2.38	125.32	48.82
25	51.95	42.13	67.98	77.25	102.86	87.99	64.72	266	215	31.48	91.00	8.04	39.26	3.08	104.66	22.10
26	47.18	40.45	66.11	72.62	72.31	60.23	48.61	267	215	30.88	80.90	6.04	38.70	3.32	104.50	28.34
27	43.90	40.31	65.76	69.82	45.46	32.16	36.34	269	215	31.94	74.50	4.10	39.82	3.22	117.94	45.70

Table 2.54: CF12 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.12	50.57	85.27	94.45	101.34	85.83	81.20	265	216	36.76	125.40	10.40	46.80	5.12	125.76	25.16
2	55.73	49.33	85.51	91.69	68.83	57.53	60.09	267	216	37.10	115.80	7.66	47.12	5.16	128.94	33.36
3	53.86	50.59	85.63	88.98	37.44	29.31	42.58	268	215	38.92	106.30	4.94	49.84	6.18	147.44	56.36
4	60.69	50.45	75.75	85.50	107.16	91.94	72.56	264	215	35.84	108.20	10.64	46.36	5.62	115.48	23.38
5	56.48	50.19	76.15	82.19	66.89	56.48	51.18	266	216	36.70	97.00	6.68	47.76	6.24	120.24	34.50
6	53.14	50.37	75.86	78.68	31.39	24.78	35.47	267	215	38.30	87.60	3.60	49.92	6.72	144.48	64.02
7	58.32	49.28	70.00	78.52	94.10	81.14	59.86	265	215	35.10	93.90	8.76	45.80	5.70	110.16	26.18
8	56.44	50.38	65.76	71.40	62.77	54.28	42.90	267	215	35.64	78.70	6.04	47.88	7.28	111.88	37.04
9	53.86	50.54	63.00	66.23	36.12	29.81	32.57	269	215	37.42	68.40	3.36	49.68	7.34	126.06	58.18
10	54.94	45.98	84.57	93.19	96.23	80.51	78.61	268	216	34.28	121.90	9.58	42.94	3.76	123.92	25.10
11	50.47	44.31	85.29	91.35	67.79	55.05	60.67	268	215	34.34	114.00	6.60	42.58	3.36	126.86	31.84
12	48.83	45.34	85.21	88.79	40.11	31.10	45.12	269	214	35.76	106.10	4.84	44.72	4.08	141.28	50.42
13	55.35	45.28	74.50	84.22	108.02	90.39	73.53	267	215	32.62	105.30	10.04	41.58	4.18	113.02	22.52
14	52.00	45.06	76.01	82.78	75.32	62.36	55.89	267	216	34.04	98.70	6.92	42.74	3.76	115.54	28.52
15	48.46	45.66	75.14	78.10	33.14	25.13	36.20	269	215	35.70	86.30	3.64	45.36	4.56	138.58	58.84
16	53.05	44.17	66.43	74.93	94.64	79.61	57.98	267	215	32.36	86.90	7.98	41.16	4.18	104.98	24.80
17	51.75	45.50	65.86	71.60	64.66	55.87	44.89	270	215	33.22	79.50	6.04	43.28	5.30	108.60	33.20
18	48.68	45.25	66.32	69.72	37.90	30.83	34.89	268	215	34.12	73.80	3.86	44.52	5.46	124.26	52.44
19	49.45	40.50	80.53	89.21	96.65	80.20	76.45	267	215	31.18	112.50	7.98	38.20	2.56	117.94	23.74
20	47.05	40.92	81.13	87.19	67.71	54.96	58.21	268	215	31.70	105.70	6.34	39.48	3.20	121.40	30.76
21	43.71	40.18	80.95	84.74	42.59	31.48	44.23	269	215	32.98	98.70	4.54	39.96	2.28	132.90	46.12
22	51.79	40.89	70.69	81.16	115.56	97.68	78.94	265	215	30.62	100.30	9.22	36.78	1.60	108.36	20.72
23	46.32	39.75	71.18	77.51	70.69	58.98	51.95	268	215	30.84	89.00	6.14	38.32	2.88	109.48	28.14
24	43.53	40.28	71.30	74.72	38.40	29.02	37.43	269	214	32.68	81.20	3.32	39.96	2.56	125.52	49.10
25	49.69	40.00	66.49	75.70	102.36	86.86	64.19	267	215	30.60	89.20	8.42	37.12	1.96	102.76	21.38
26	47.25	40.43	66.17	72.70	72.62	61.17	49.22	267	215	30.72	81.60	6.32	38.48	3.22	104.78	28.22
27	43.59	39.89	66.27	70.09	42.61	32.88	36.90	268	214	31.62	75.10	4.12	39.40	3.12	117.28	44.66

Table 2.55: CF20 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.00	50.39	85.08	94.33	101.68	86.20	80.39	264	215	37.54	123.20	8.80	46.88	4.50	125.32	25.90
2	55.55	49.32	85.26	91.38	67.82	55.95	59.20	266	216	37.62	115.60	7.42	47.26	4.74	128.82	33.38
3	53.62	50.39	85.37	88.71	36.99	28.86	42.33	266	215	39.34	106.20	4.78	49.68	5.48	146.94	56.14
4	60.21	50.37	74.87	84.38	103.88	88.47	69.62	262	216	36.04	106.70	10.20	46.56	5.54	115.02	23.82
5	56.55	50.53	75.66	81.52	64.39	53.97	49.46	264	215	37.78	95.90	6.34	48.36	5.62	120.46	35.00
6	52.64	49.90	75.77	78.61	31.15	24.56	35.42	263	215	38.68	87.30	3.62	49.52	5.98	143.76	63.34
7	57.34	49.05	68.04	76.05	87.64	74.42	54.56	263	215	35.74	88.70	7.80	46.02	5.34	108.84	27.54
8	56.19	50.32	65.44	71.01	61.39	52.84	42.08	265	216	36.44	78.42	5.80	48.16	6.74	111.88	37.26
9	53.62	50.29	62.95	66.22	36.23	29.84	32.60	266	215	37.38	68.70	3.42	49.50	7.28	126.30	57.80
10	54.25	45.52	84.00	92.55	94.53	78.22	74.48	265	215	35.00	116.10	6.34	42.98	2.94	121.52	25.44
11	50.12	44.16	85.21	91.24	66.45	53.30	59.65	265	215	34.96	113.30	6.14	42.82	2.80	126.92	32.32
12	48.58	45.17	85.06	88.67	40.10	30.54	44.65	267	215	35.72	105.90	4.68	44.68	4.00	141.82	50.94
13	55.13	45.15	74.34	84.04	106.70	89.36	72.83	264	215	33.20	105.30	9.56	41.74	3.74	112.56	22.00
14	50.78	44.23	75.24	81.75	71.77	58.77	53.88	265	215	34.00	96.80	6.50	42.28	3.34	115.10	29.42
15	48.29	45.50	75.02	78.00	33.10	24.96	36.08	267	215	36.14	86.30	3.56	45.32	4.28	138.46	58.60
16	53.18	44.20	66.73	75.44	95.87	80.66	58.66	264	216	32.90	88.10	7.78	41.42	3.80	105.22	24.36
17	51.47	45.27	65.57	71.47	65.80	55.62	44.79	268	215	33.44	79.20	5.78	43.06	4.74	108.40	33.20
18	48.36	45.19	65.26	68.52	36.14	28.47	33.57	266	215	35.20	72.10	3.60	44.72	4.58	124.96	54.28
19	48.75	39.92	79.66	88.36	95.94	78.95	74.55	265	215	31.66	110.40	7.52	37.02	0.78	114.90	21.68
20	46.30	40.26	80.41	86.51	67.33	54.01	57.26	265	215	32.48	104.60	6.24	39.06	1.92	119.14	28.96
21	43.74	40.28	80.18	83.94	41.78	30.78	42.84	266	214	33.58	96.40	3.32	40.02	1.70	131.56	45.96
22	50.88	40.44	69.31	79.42	111.06	93.89	73.28	264	216	30.90	97.20	9.06	36.58	1.26	106.14	20.14
23	45.44	39.23	69.38	75.60	69.14	55.46	49.41	267	215	30.86	86.00	6.18	38.00	2.70	108.52	28.98
24	43.43	40.33	70.56	73.92	37.44	27.79	36.57	266	214	33.44	79.60	3.02	40.28	1.98	125.26	49.88
25	49.50	40.20	65.78	74.71	98.16	83.21	61.67	264	215	30.86	87.70	8.32	37.74	2.48	102.60	22.00
26	47.07	40.24	66.04	72.78	74.06	61.15	49.14	264	215	31.48	82.20	6.26	38.82	2.74	104.62	27.68
27	43.61	39.95	66.31	70.17	42.48	32.62	36.83	264	214	31.78	75.30	4.22	39.56	3.06	117.78	44.96

Table 2.56: CF30 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.35	50.95	85.49	94.72	100.74	84.24	81.99	262	215	37.24	125.60	9.00	47.22	5.10	127.96	27.46
2	55.95	49.69	85.53	91.69	67.47	55.97	59.97	263	215	37.22	117.20	7.82	47.46	5.32	130.78	34.30
3	53.48	50.23	85.69	89.08	37.10	29.15	42.91	263	215	38.76	107.40	5.30	49.54	5.92	148.04	56.38
4	60.74	50.55	75.85	85.87	108.42	91.36	74.53	260	215	35.90	111.80	11.04	46.44	5.64	117.28	23.56
5	56.42	50.14	76.27	82.47	67.30	56.37	51.82	261	215	37.06	98.70	7.02	47.84	5.94	121.10	34.08
6	52.61	49.88	76.00	78.89	31.48	24.63	35.79	262	216	38.74	88.30	3.88	49.52	5.96	143.84	62.88
7	58.67	49.46	70.69	79.52	96.12	82.82	62.29	261	216	35.42	97.60	9.10	45.90	5.46	111.84	25.50
8	56.65	50.57	66.23	71.96	63.10	54.36	43.85	264	215	36.18	80.90	6.22	48.20	7.16	112.86	36.64
9	53.90	50.42	63.73	67.17	37.82	31.20	33.61	264	215	37.36	71.10	3.90	49.46	7.10	125.52	55.92
10	54.69	45.91	84.89	93.53	94.64	78.60	78.77	263	215	34.84	120.30	7.32	43.12	3.26	124.98	26.86
11	50.79	44.76	85.75	91.82	66.46	54.01	61.02	263	215	34.68	116.30	6.88	43.04	3.32	128.76	32.92
12	48.31	44.95	85.26	88.87	39.76	30.04	44.65	264	215	35.88	106.50	4.74	44.42	3.66	142.06	50.76
13	55.95	45.50	75.89	86.14	111.88	94.13	78.98	262	216	33.58	111.20	9.88	42.06	3.66	115.40	22.00
14	51.88	45.14	76.22	82.90	73.28	60.29	55.50	263	215	34.40	100.30	6.84	43.00	3.66	116.74	29.20
15	48.42	45.57	75.80	78.79	32.84	25.58	36.68	264	215	35.84	88.10	3.50	45.30	4.54	139.08	58.26
16	55.01	44.80	70.61	80.48	107.28	91.63	70.00	261	215	33.12	100.30	9.24	41.58	3.66	109.40	21.76
17	51.53	45.11	66.57	72.80	68.85	57.47	46.77	265	215	33.76	82.10	6.36	43.04	4.46	108.64	31.32
18	48.81	45.37	66.75	70.25	38.56	30.74	35.20	264	215	34.56	75.10	4.26	44.76	5.26	125.12	52.24
19	49.27	40.32	81.07	90.00	97.60	80.27	79.74	262	215	32.18	112.50	6.20	37.58	0.80	115.56	21.56
20	46.55	40.45	81.16	87.33	67.85	54.64	58.49	264	215	32.24	106.90	6.26	39.36	2.50	121.66	30.32
21	44.08	40.68	80.67	84.40	41.15	30.36	43.66	265	214	33.12	98.70	4.66	40.30	2.46	134.46	47.42
22	51.84	40.95	70.85	81.49	115.58	97.46	80.64	261	215	31.04	102.70	9.34	36.64	0.92	109.40	20.20
23	45.95	39.36	71.28	77.78	71.56	58.90	52.45	264	215	31.72	90.82	6.32	37.86	1.48	109.68	27.20
24	43.84	40.66	71.43	74.88	38.07	28.44	37.51	265	214	33.22	82.20	4.08	40.44	2.36	126.64	49.72
25	48.53	39.15	65.04	74.13	99.60	83.76	62.86	263	214	30.66	87.80	8.58	36.16	1.00	101.54	20.84
26	46.58	40.13	64.88	71.24	69.61	57.64	47.10	263	215	31.56	80.00	6.00	38.90	2.70	104.58	28.94
27	43.64	40.30	64.53	68.06	38.60	29.83	35.09	263	214	32.14	72.10	4.06	39.88	3.20	119.16	48.26

Table 2.57: CF45 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.93	51.77	85.33	94.59	97.86	82.01	81.53	254	215	37.74	131.00	10.14	48.08	5.48	129.86	26.76
2	55.32	49.15	85.51	91.89	68.04	55.29	61.35	256	215	37.06	119.50	7.58	47.04	5.08	131.72	34.02
3	53.90	50.76	85.56	88.99	36.66	28.16	42.52	257	215	39.38	108.10	5.32	50.18	5.92	149.08	57.34
4	60.70	50.37	75.88	86.37	110.78	92.59	77.36	253	215	36.34	116.00	11.06	46.36	5.22	119.12	23.18
5	56.53	50.38	76.23	82.53	66.91	55.02	51.88	255	215	37.22	100.10	6.68	48.08	5.96	122.62	35.02
6	52.74	50.10	75.91	78.80	30.61	23.53	35.56	254	214	39.12	89.30	3.96	49.68	5.92	145.50	63.86
7	59.13	50.08	70.79	79.80	95.36	81.14	63.24	254	215	35.78	100.60	9.16	46.52	5.72	113.60	25.84
8	56.27	50.20	66.18	72.06	63.33	54.26	44.18	258	215	36.36	82.10	5.78	47.84	6.50	113.10	36.06
9	53.52	49.92	63.70	67.33	38.76	32.32	34.07	257	215	36.72	72.00	4.30	48.92	7.20	125.08	54.60
10	55.19	46.80	84.49	93.05	91.17	75.08	77.64	256	215	35.24	122.30	7.52	44.06	3.94	127.58	28.48
11	50.76	44.90	85.39	91.54	65.81	52.46	60.82	257	215	34.54	117.60	6.88	43.04	3.56	130.82	34.08
12	48.75	45.47	85.06	88.67	38.82	29.48	44.20	258	216	36.20	106.60	4.50	44.92	3.84	143.98	52.78
13	55.89	45.73	75.48	85.81	109.78	91.14	80.21	255	215	33.42	114.10	10.40	42.18	3.90	117.62	22.60
14	51.65	45.03	76.04	82.82	72.12	59.31	55.92	255	215	34.20	101.40	6.58	42.86	3.84	118.22	29.82
15	48.30	45.54	75.37	78.44	32.90	24.68	36.46	257	215	36.16	88.50	3.88	45.34	4.24	140.02	58.90
16	54.41	44.67	69.43	79.15	103.08	87.20	67.85	255	215	32.70	99.80	8.64	41.46	4.04	109.78	22.34
17	51.41	45.16	66.20	72.40	66.40	55.88	46.35	257	215	34.12	82.60	5.90	43.20	4.04	109.44	32.08
18	48.36	45.10	66.11	69.55	36.76	29.27	34.46	256	215	35.12	74.40	3.52	44.58	4.50	125.32	53.34
19	49.01	40.33	80.16	89.07	94.77	77.61	77.38	255	214	32.14	112.00	5.22	37.50	0.76	117.78	23.80
20	46.72	40.83	80.90	87.13	66.48	52.86	58.02	256	215	32.24	108.30	5.86	39.88	2.90	123.28	31.32
21	43.98	40.61	80.15	83.97	40.95	30.21	43.22	258	215	32.98	98.50	4.14	40.38	2.66	134.82	48.34
22	51.28	40.75	69.72	80.31	112.12	94.29	77.18	254	215	30.78	102.40	8.38	36.94	1.64	109.60	20.54
23	45.47	39.39	69.32	75.61	67.19	54.34	49.58	256	215	31.26	87.90	5.78	38.28	2.56	110.12	29.40
24	43.20	40.27	69.36	72.75	36.26	26.20	35.79	257	215	32.68	79.00	3.14	40.06	2.70	127.72	52.76
25	47.69	39.18	62.61	71.12	90.95	76.35	56.76	257	215	30.40	83.70	7.06	37.06	2.10	101.50	23.40
26	47.11	40.75	64.89	71.34	68.70	56.81	47.43	256	214	31.24	80.70	5.50	39.14	3.38	106.22	30.04
27	43.68	40.51	63.90	67.40	37.25	28.31	34.22	255	215	32.36	71.20	3.54	40.16	3.10	120.86	50.56

## 2.7 Non-Condensables in Refrigerant

Nitrogen was added to the system to simulate non-condensables in the refrigerant. The amount of nitrogen present in the system for each of the fault levels is shown in Table 2.58. The fault level testing was run in reverse order, with the most severe fault tested first. Each subsequent fault was then tested after purging some nitrogen out of the system. The actual amount of nitrogen in the system for each fault case was determined using Dalton's law of additive pressures. The uncertainty in the calculation was  $\pm 0.05$  pounds (or about  $\pm 0.5\%$  by volume when calculated at a temperature of 72°F). The error in characterizing this fault is significant; nevertheless, it arises because it takes very little nitrogen to develop some adverse responses from the chiller. Even the mildest fault level is easily detected.

**Table 2.58: Fault levels for non-condensables in refrigerant**

<b>Case</b>	<b>Desired Condition</b>	<b>Actual Condition</b>
<b>Normal Operation</b>	No Nitrogen	No Nitrogen
<b>Fault Level 1</b>	1% by volume Nitrogen	0.10 pounds (1.0%)
<b>Fault Level 2</b>	2% by volume Nitrogen	0.16 pounds (1.7%)
<b>Fault Level 3</b>	3% by volume Nitrogen	0.22 pounds (2.4%)
<b>Fault Level 4</b>	5% by volume Nitrogen	0.54 pounds (5.7%)

Non-condensables is normally just air that is accidentally introduced into the refrigerant during servicing. For this study, laboratory grade nitrogen was chosen in order to avoid the risk of moisture contamination associated with introducing air into the system. The substitution is validated by the fact that air is about 79% nitrogen, and the molecular weight of nitrogen is only 2% less than that of air.

Two additional faults were also tested with trace amounts of nitrogen. Although it cannot be determined how much nitrogen was in the system, the 'NC Trace2' test run was run after purging some nitrogen from the 'NC Trace' test run. The 'Modified NC' test run eliminated all low load tests and replaced them with the mid-level load tests.

**Table 2.59: NC1 test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.09	50.87	85.39	94.19	97.72	82.75	81.15	267	215	37.64	129.12	11.98	47.66	5.08	129.68	27.30
2	55.61	49.31	85.56	91.69	68.60	56.32	61.95	269	215	37.54	121.70	10.38	47.38	4.84	132.90	34.34
3	53.76	50.38	85.75	89.21	38.79	30.37	44.22	269	216	39.24	112.50	7.80	49.92	5.86	150.66	56.34
4	60.92	50.62	75.92	85.70	107.62	92.53	75.16	264	216	36.36	115.42	13.78	46.80	5.54	119.20	23.76
5	56.96	50.73	76.32	82.33	66.69	55.82	52.84	266	215	38.02	103.80	10.14	48.82	5.84	125.02	35.46
6	52.98	50.16	76.05	78.98	32.28	25.20	36.71	265	215	38.76	93.50	6.86	49.96	6.44	148.62	64.54
7	59.21	49.55	71.92	81.13	101.82	86.67	67.36	265	215	36.38	105.60	13.06	46.26	4.94	115.06	24.32
8	56.29	50.11	66.33	72.08	64.89	55.30	45.95	271	215	36.82	87.20	10.84	48.04	6.46	116.04	35.68
9	53.85	49.82	65.14	68.97	42.88	36.02	37.00	269	215	36.90	79.50	8.18	48.86	7.08	126.68	51.22
10	54.29	46.10	85.09	92.96	87.64	73.45	76.39	267	215	35.32	127.00	11.76	43.74	3.50	128.44	27.32
11	51.14	45.03	85.96	92.01	67.45	54.53	63.57	268	214	35.08	122.30	10.20	43.40	3.36	132.78	33.74
12	48.50	45.08	85.31	88.96	40.91	30.56	46.55	269	214	35.92	112.70	8.08	44.68	3.84	146.42	52.22
13	56.49	46.38	76.16	85.94	107.62	90.98	78.83	264	216	34.34	115.72	13.44	43.06	3.68	118.48	22.76
14	51.30	44.50	76.15	82.75	73.58	61.05	57.56	268	215	34.28	105.50	10.68	42.50	3.42	120.14	29.66
15	48.55	45.68	75.78	78.83	34.03	25.71	37.75	268	215	36.44	93.80	7.18	45.40	4.10	142.42	58.52
16	55.04	45.02	70.78	80.30	105.42	89.41	70.50	266	214	33.60	104.90	13.24	42.06	3.58	112.38	22.06
17	51.40	44.94	66.47	72.61	69.29	57.58	48.62	271	214	33.96	88.50	10.88	42.98	4.14	112.36	31.38
18	48.41	44.98	66.45	69.99	39.39	30.54	36.12	267	214	35.32	80.50	8.02	44.56	4.18	128.90	52.86
19	48.64	40.52	80.35	88.18	87.71	72.65	71.62	269	215	32.26	117.40	12.66	39.12	2.14	121.68	25.04
20	47.15	41.11	81.09	87.15	67.53	53.97	60.02	268	215	32.80	113.10	10.88	40.18	2.68	126.24	31.68
21	44.24	40.83	80.57	84.35	42.38	30.51	45.05	269	214	33.32	104.20	8.18	40.58	2.52	138.46	48.68
22	51.76	41.55	71.07	80.57	107.02	91.65	75.62	270	216	31.24	105.80	13.62	39.00	3.28	112.68	21.90
23	46.41	39.95	71.19	77.46	70.16	57.72	54.03	269	214	31.02	96.20	10.74	38.58	3.06	114.98	29.52
24	43.36	40.10	71.31	74.87	39.85	29.09	39.12	269	214	32.66	87.70	8.12	39.94	2.58	130.16	49.46
25	50.06	40.52	66.63	75.67	100.76	85.28	66.07	267	215	30.56	96.70	13.80	38.12	3.00	108.08	22.38
26	47.20	40.46	66.23	72.79	73.05	60.37	51.39	267	215	31.76	89.20	11.86	39.18	2.86	109.44	28.14
27	43.73	40.14	66.28	70.11	42.68	32.04	38.28	267	215	32.34	81.00	8.66	39.86	2.76	122.88	46.58

Table 2.60: NC2 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	61.01	51.84	85.55	94.31	97.14	82.41	80.79	266	216	38.66	133.50	13.92	48.72	5.24	130.44	26.08
2	56.24	50.00	85.55	91.62	67.90	55.89	61.97	268	215	37.74	123.40	11.46	48.04	5.34	135.06	35.38
3	53.87	50.54	85.73	89.21	38.94	29.84	44.45	269	215	39.54	113.90	8.58	50.04	5.68	152.34	57.18
4	60.89	50.58	75.93	85.73	107.98	92.53	76.88	265	215	36.44	117.70	14.90	46.84	5.46	120.62	23.82
5	56.36	50.17	76.07	82.07	66.64	55.56	53.35	267	215	37.74	105.00	11.24	48.26	5.62	125.54	35.08
6	52.81	50.08	75.77	78.69	32.51	24.50	36.87	267	215	38.86	95.00	7.80	49.84	6.14	149.84	65.32
7	58.49	49.99	69.51	77.51	88.71	76.28	59.32	266	215	36.66	100.40	13.18	47.00	5.40	115.02	27.26
8	56.27	50.23	65.89	71.39	62.15	54.28	45.37	271	216	35.86	87.30	11.52	48.20	7.34	118.34	37.94
9	53.37	49.90	63.11	66.47	37.63	31.13	34.57	269	215	37.66	76.80	9.06	49.22	6.68	130.68	56.76
10	55.09	47.09	84.50	92.25	86.92	71.70	75.34	269	215	35.52	126.78	12.52	44.60	4.00	129.78	28.38
11	52.04	45.84	85.72	91.90	69.04	55.43	64.78	268	214	35.30	124.10	11.38	44.14	3.90	133.92	33.84
12	49.12	45.50	85.06	88.84	42.46	32.35	48.17	270	215	35.40	115.18	9.36	44.98	4.68	149.32	53.80
13	57.22	47.05	75.84	85.59	108.50	91.16	79.20	267	215	34.98	117.30	14.48	43.80	3.86	119.28	22.60
14	51.20	44.18	76.26	83.17	77.16	62.77	60.06	268	215	34.32	108.80	12.34	42.36	3.12	120.68	28.32
15	48.09	45.18	75.74	78.83	34.58	25.99	38.52	269	215	36.28	95.40	8.26	45.02	3.78	142.88	57.84
16	55.96	45.71	71.33	81.13	108.86	91.80	74.67	267	215	33.58	109.30	14.58	42.34	4.06	114.74	22.40
17	51.52	45.01	66.73	73.01	70.84	58.20	49.88	271	215	34.22	90.94	12.16	42.98	3.96	113.58	31.24
18	48.57	45.18	66.54	70.10	39.66	30.27	36.76	268	214	35.76	82.80	9.20	44.68	4.10	130.06	52.56
19	49.25	41.04	80.87	88.86	89.18	73.43	74.20	268	215	32.94	120.60	13.86	39.54	1.88	123.72	25.46
20	47.18	41.07	81.13	87.28	68.82	54.82	61.23	269	215	33.06	115.26	11.68	40.12	2.32	127.40	31.88
21	44.30	40.94	80.56	84.33	42.34	30.02	45.23	269	214	33.46	105.30	8.78	40.54	2.32	139.20	48.78
22	53.38	43.17	71.08	80.80	107.58	91.59	76.19	266	215	32.00	108.70	14.68	40.16	3.54	114.32	22.18
23	46.49	40.06	71.21	77.46	69.92	57.54	54.56	269	215	31.34	98.20	12.16	38.78	2.94	116.24	29.66
24	43.77	40.55	71.26	74.78	39.55	28.85	39.06	270	215	33.02	89.10	8.86	40.40	2.60	131.80	50.42
25	50.30	40.81	66.76	75.81	101.00	85.21	67.06	268	215	30.82	99.20	15.00	38.44	3.06	109.32	22.28
26	47.15	40.47	66.13	72.64	72.57	59.63	51.90	268	214	31.54	90.92	12.74	39.14	3.04	110.98	28.58
27	43.82	40.32	66.15	69.91	41.97	31.27	37.99	268	214	32.72	82.10	9.46	40.02	2.58	123.86	46.98

Table 2.61: NC3 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	61.07	52.09	85.27	93.91	95.72	80.31	79.67	266	215	39.04	130.50	12.96	49.06	5.22	131.34	28.44
2	55.99	49.90	85.32	91.39	67.41	54.75	61.83	267	215	38.42	124.60	12.20	48.10	4.90	135.78	35.86
3	53.41	50.08	85.45	88.99	39.53	29.88	45.17	268	215	39.24	114.90	9.54	49.54	5.48	152.82	57.06
4	61.26	50.97	75.90	85.75	108.68	92.34	77.46	265	215	37.26	119.90	15.80	47.34	5.08	121.46	23.46
5	56.48	50.19	76.22	82.37	68.01	56.35	54.64	265	215	37.50	107.80	12.38	48.26	5.90	127.16	35.32
6	53.13	50.37	75.87	78.82	32.65	24.68	37.19	266	215	39.34	96.60	8.88	50.10	5.94	151.06	65.32
7	58.97	49.60	71.07	79.97	98.43	84.04	66.43	265	215	37.02	108.10	15.06	46.60	4.64	116.38	24.64
8	56.07	49.88	66.20	71.99	65.21	55.60	47.17	270	215	36.82	90.46	12.72	47.82	6.10	118.04	35.86
9	53.55	50.00	63.26	66.75	39.01	31.73	35.39	269	215	37.98	79.40	10.22	49.34	6.50	131.02	55.64
10	54.96	47.19	84.10	91.67	84.32	69.63	73.81	268	215	35.98	128.14	13.64	44.82	3.94	130.28	28.50
11	50.48	44.39	85.47	91.61	68.30	54.18	65.73	267	214	34.98	125.70	12.48	42.92	2.92	135.24	34.68
12	48.64	45.30	85.10	88.77	41.09	29.90	47.90	269	215	36.28	115.92	9.84	45.62	4.48	149.26	53.72
13	56.89	47.10	75.17	84.57	104.64	87.54	76.94	267	215	34.44	117.20	15.50	43.70	4.32	120.12	23.64
14	51.23	44.39	75.93	82.68	75.32	61.21	59.46	268	215	34.46	109.50	13.00	42.62	3.20	122.56	29.82
15	48.65	45.85	75.19	78.26	34.46	25.05	38.06	269	215	36.66	96.10	9.24	45.64	4.10	145.66	60.22
16	54.74	45.06	69.68	78.88	102.30	86.88	69.52	267	215	33.62	106.60	15.16	42.08	3.66	114.10	23.08
17	51.50	45.34	65.76	71.59	65.70	55.03	48.20	270	215	33.78	90.20	12.96	43.52	4.82	115.80	33.82
18	48.26	45.00	65.43	68.81	37.63	29.25	35.94	267	215	35.00	82.40	10.30	44.64	4.68	132.06	54.84
19	49.36	41.60	79.60	87.25	85.65	69.37	71.19	269	215	32.70	119.30	14.08	40.16	2.66	124.82	27.24
20	46.63	40.53	80.60	86.75	68.84	54.34	60.93	268	214	32.90	115.08	12.38	39.66	2.00	127.28	32.02
21	44.69	41.34	80.00	83.78	42.37	29.97	45.52	269	214	33.60	106.50	10.22	40.92	2.50	141.74	50.60
22	52.21	42.16	70.02	79.62	106.78	90.27	74.92	267	215	32.18	109.00	16.62	39.82	2.96	114.06	21.68
23	45.99	39.88	69.67	75.76	68.39	54.63	52.82	269	214	31.40	96.80	13.16	38.70	2.70	116.94	31.12
24	42.94	39.91	69.54	73.00	38.85	27.16	37.68	269	215	32.90	85.90	8.50	39.86	2.34	131.02	51.46
25	49.15	40.52	64.10	72.32	91.73	77.36	60.56	268	215	31.34	94.30	15.90	38.62	2.72	108.14	23.88
26	47.15	40.79	64.88	71.17	70.20	56.76	50.16	268	214	32.10	90.20	13.88	39.60	2.82	111.88	29.86
27	43.70	40.38	64.55	68.20	40.86	29.62	36.98	268	214	32.90	80.50	9.84	40.04	2.48	125.38	49.26

Table 2.62: NC5 test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	58.81	51.41	84.91	92.15	80.93	66.37	74.29	268	215	38.66	136.20	17.02	49.00	5.56	138.66	33.14
2	55.79	49.95	85.35	91.18	65.38	52.40	64.57	269	215	37.80	131.20	15.44	48.20	5.38	142.88	39.82
3	55.80	50.12	85.06	90.75	63.88	50.90	62.70	269	215	38.28	130.10	15.36	48.46	5.26	142.84	40.32
4	60.27	50.71	74.77	84.08	102.60	85.75	75.50	265	215	37.08	123.40	19.22	47.26	5.26	124.72	25.36
5	55.83	50.67	74.38	79.50	56.90	46.25	50.23	266	215	38.18	108.50	15.32	49.10	6.00	134.10	42.10
6	54.48	50.12	75.57	79.97	48.65	39.08	46.81	266	215	38.02	107.90	14.26	49.06	6.08	140.02	48.36
7	58.04	49.24	69.71	78.23	94.33	78.98	65.71	266	215	36.54	111.60	18.62	46.44	4.94	119.76	25.92
8	56.41	50.50	65.91	71.46	62.70	53.04	48.22	272	215	36.06	96.00	16.48	48.54	7.42	124.48	39.22
9	53.72	50.12	63.27	66.88	40.42	32.37	37.41	268	216	38.12	86.10	14.78	49.44	6.46	135.00	55.32
10	54.21	47.90	84.04	90.32	70.52	56.70	68.81	269	216	36.54	130.60	16.14	46.06	4.64	139.90	36.94
11	52.13	46.61	85.05	90.74	63.62	49.36	65.72	268	215	36.06	129.80	15.10	45.14	4.18	144.38	41.74
12	50.59	45.58	85.56	90.90	59.63	44.91	63.55	269	215	35.90	129.30	14.78	44.38	3.58	147.14	44.74
13	55.75	47.06	75.21	83.46	94.61	77.89	74.85	275	215	33.44	121.00	18.38	43.94	5.60	127.16	28.64
14	50.91	44.37	75.60	82.15	73.03	58.79	61.60	268	216	34.04	115.28	16.46	42.44	3.68	127.82	32.14
15	49.57	45.23	75.83	80.35	50.26	38.91	48.75	267	215	35.66	109.10	14.42	44.34	3.62	137.30	44.88
16	54.86	45.63	69.08	78.05	99.27	82.67	69.67	266	215	34.00	112.20	19.06	42.86	3.94	118.02	24.02
17	51.16	45.07	65.62	71.60	67.29	54.62	50.59	270	216	34.72	96.80	16.76	43.24	3.58	119.32	33.62
18	49.24	45.73	65.58	69.24	40.57	31.37	38.91	267	215	35.28	90.40	14.70	45.10	4.80	134.64	52.48
19	47.53	41.16	79.34	85.94	74.03	57.05	66.72	269	215	32.98	122.10	16.80	40.14	2.46	131.68	32.76
20	47.63	41.99	80.38	86.27	66.06	50.59	63.81	269	215	32.98	121.70	15.90	40.68	2.98	136.92	38.14
21	47.70	42.04	80.88	86.74	65.72	50.67	64.51	269	215	33.16	122.80	15.76	40.86	2.86	138.10	38.60
22	51.57	42.10	70.22	79.30	102.16	85.15	76.70	270	216	32.16	115.18	19.88	39.80	3.04	119.66	24.08
23	44.85	39.18	69.74	75.62	65.79	50.60	53.47	268	214	31.38	101.10	16.00	38.36	2.40	121.36	33.12
24	44.03	40.46	70.08	74.01	44.19	31.98	42.69	269	215	32.90	95.90	13.84	40.14	2.50	133.14	47.94
25	47.10	39.13	63.24	70.91	88.03	71.72	59.18	275	216	30.64	96.70	18.74	37.34	2.24	110.72	24.92
26	47.20	41.30	64.63	70.51	65.82	53.02	51.71	268	216	31.46	95.30	16.84	39.68	3.72	118.18	33.46
27	44.13	40.19	64.86	69.09	47.03	35.17	42.08	267	214	32.36	90.18	15.16	39.72	2.66	126.08	44.22

**Table 2.63: NC Trace test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	59.63	50.41	85.03	93.71	96.42	82.46	75.41	267	215	37.42	123.80	9.74	47.22	4.86	124.44	24.56
2	56.03	49.87	85.06	90.88	64.83	55.18	57.75	268	215	37.26	114.70	7.66	47.84	5.80	130.58	35.36
3	53.61	50.31	85.29	88.55	36.46	29.51	42.15	268	215	39.04	106.30	5.12	49.84	6.04	148.12	56.88
4	60.53	50.59	75.06	84.30	101.92	89.03	68.66	265	215	35.96	106.20	10.16	46.88	6.04	115.64	24.66
5	56.44	50.45	75.48	81.17	63.06	53.55	49.35	266	214	36.76	96.50	7.12	48.38	6.76	121.96	36.38
6	52.96	50.31	75.42	78.18	30.65	23.71	34.96	267	215	38.98	87.90	4.36	50.04	6.26	146.14	65.52
7	57.65	49.22	68.49	76.33	87.04	75.55	55.51	267	215	36.26	90.66	8.78	46.44	5.36	109.62	27.36
8	56.28	50.08	65.91	71.51	63.40	55.37	43.86	272	214	35.98	80.70	7.08	47.88	6.92	112.28	36.10
9	53.66	50.43	62.60	65.67	34.33	28.90	32.11	268	215	37.28	69.50	4.44	49.84	7.70	129.18	60.44
10	53.07	45.07	82.59	90.17	84.61	71.77	67.41	268	215	34.52	115.34	8.58	42.90	3.46	120.72	25.04
11	50.82	44.83	85.08	90.93	65.26	53.70	59.53	268	215	34.60	114.60	7.24	43.16	3.52	128.58	33.46
12	48.49	45.02	84.80	88.38	39.96	30.92	44.89	268	214	35.84	106.80	5.54	44.48	3.68	142.00	50.52
13	55.40	45.55	74.81	84.21	103.82	88.00	71.59	265	214	33.74	105.80	10.00	42.42	3.94	113.10	22.18
14	52.02	44.99	76.20	82.90	74.71	63.08	56.58	267	215	33.88	100.60	7.86	42.80	3.92	116.68	28.96
15	48.26	45.36	75.34	78.33	33.46	25.99	36.69	268	215	35.70	88.70	4.68	45.22	4.46	139.58	58.42
16	55.59	45.29	71.07	80.71	106.72	92.16	70.20	266	215	32.92	99.90	10.06	41.88	4.32	109.76	22.36
17	51.75	45.48	66.33	72.17	65.86	56.11	45.70	270	214	33.66	82.00	7.22	43.56	5.08	109.76	32.92
18	48.60	45.22	66.43	69.83	37.98	30.22	34.98	268	215	35.34	75.90	5.14	44.84	4.54	125.96	52.72
19	48.40	40.22	80.16	88.00	87.20	73.10	67.97	267	214	32.20	111.40	10.04	38.58	1.80	116.86	23.24
20	47.05	40.95	81.04	87.06	67.02	54.52	58.00	267	215	32.24	107.10	7.58	39.86	2.90	122.62	31.18
21	43.73	40.14	80.95	84.75	42.66	32.13	44.28	269	215	33.12	98.80	4.50	40.02	2.18	132.66	46.00
22	51.11	40.53	71.11	80.90	110.70	94.71	74.60	272	215	30.84	100.70	11.28	37.98	2.60	108.64	20.68
23	46.05	39.45	71.21	77.52	70.51	58.93	52.21	268	214	31.52	90.54	7.86	38.28	2.28	110.36	28.20
24	43.41	40.24	71.05	74.42	37.80	28.35	37.44	270	214	32.74	83.20	5.54	40.02	2.62	127.56	49.70
25	50.09	40.52	66.55	75.56	100.08	85.16	63.46	267	214	30.62	90.64	10.48	38.04	2.98	104.58	22.16
26	47.13	40.40	66.16	72.58	71.59	60.04	49.19	267	214	31.30	83.40	8.30	38.94	3.10	105.98	27.96
27	43.90	40.41	66.09	69.74	40.50	31.22	36.39	267	214	32.86	75.80	5.14	40.10	2.64	119.36	46.40

**Table 2.64: NC Trace 2 test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	60.73	50.84	85.69	95.03	103.62	88.81	82.06	266	215	37.34	126.30	10.18	47.28	5.14	125.36	24.30
2	55.81	49.55	85.19	91.12	66.31	55.99	58.20	269	215	37.82	114.00	6.98	47.66	5.02	128.76	33.96
3	53.26	49.91	85.49	88.88	37.93	30.02	42.80	269	215	38.66	106.20	4.84	49.34	5.92	146.66	55.90
4	60.73	50.41	75.83	85.53	107.00	92.47	72.03	265	215	36.40	107.80	9.94	46.68	5.38	115.02	23.20
5	57.01	50.68	76.33	82.34	66.70	56.76	51.11	266	215	37.46	97.80	6.70	48.58	6.30	120.88	34.58
6	52.96	50.19	75.92	78.74	31.46	24.78	35.68	267	215	38.74	88.40	4.14	49.84	6.28	144.64	63.58
7	59.26	49.86	71.32	80.07	96.89	84.18	62.21	266	215	36.42	96.90	8.90	46.68	5.32	111.18	25.28
8	56.46	50.42	66.27	71.74	61.80	54.07	43.15	271	215	36.50	80.20	6.50	48.30	6.96	112.82	36.78
9	53.65	49.90	64.25	67.74	39.24	33.40	34.36	269	214	37.28	72.20	4.56	49.08	6.82	123.68	52.98
10	55.44	46.31	85.43	94.16	97.25	81.72	80.19	267	215	35.04	123.50	9.22	43.60	3.50	124.32	24.60
11	50.98	44.83	85.84	91.81	66.70	55.03	60.45	268	215	35.14	115.46	7.08	43.16	3.16	128.02	32.18
12	49.01	45.53	85.32	88.92	40.39	31.12	44.82	269	214	35.94	106.90	5.04	45.06	4.26	142.54	51.04
13	56.52	45.68	76.20	86.53	114.66	97.02	80.27	266	215	33.92	110.60	10.04	42.34	3.54	114.66	21.46
14	51.48	44.66	76.18	82.73	73.23	60.74	55.30	268	214	33.96	98.90	7.14	42.58	4.06	116.38	29.28
15	48.37	45.47	75.62	78.59	33.36	25.88	36.83	269	214	36.18	88.40	4.42	45.22	4.14	139.12	58.04
16	55.38	45.13	71.05	80.72	107.28	91.79	69.48	266	215	33.30	98.90	9.42	41.90	3.74	108.80	21.78
17	51.77	45.40	66.37	72.27	66.74	56.93	45.81	272	215	33.76	81.40	6.72	43.44	4.92	109.04	32.52
18	48.39	44.89	66.51	69.97	38.80	31.15	35.29	269	214	35.22	75.50	4.56	44.48	4.18	124.38	51.48
19	49.58	40.40	80.88	89.61	97.52	82.16	77.20	268	215	31.74	114.20	9.88	38.54	2.18	118.10	23.00
20	47.06	40.99	81.06	87.00	66.48	54.01	57.32	269	214	32.58	106.10	7.24	40.02	2.80	122.00	31.10
21	44.28	40.84	80.70	84.37	41.31	30.65	43.82	270	214	33.08	98.70	4.92	40.46	2.58	134.28	47.68
22	52.11	41.05	71.18	81.56	114.98	98.74	77.64	266	214	31.34	101.50	11.22	38.32	2.32	108.76	20.22
23	46.00	39.37	71.21	77.51	70.49	59.31	51.71	269	215	31.64	89.70	7.52	38.32	2.16	109.44	27.64
24	43.86	40.69	71.21	74.58	37.91	28.37	37.06	270	215	33.44	81.40	3.68	40.50	2.22	126.58	49.92
25	50.30	40.46	66.95	76.11	102.10	87.80	64.97	267	214	30.48	90.92	9.96	37.90	3.04	104.18	21.90
26	46.79	40.06	65.71	72.08	71.14	60.02	48.14	268	214	31.52	81.60	7.68	38.78	2.60	104.86	28.12
27	43.86	40.46	65.34	68.83	39.04	30.25	35.48	268	214	32.54	73.40	4.40	40.12	3.02	119.36	48.06

**Table 2.65: Modified NC test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	62.24	54.04	85.20	92.99	87.06	73.64	77.60	268	216	40.34	139.80	18.00	51.32	6.22	138.54	31.30
2	56.46	50.24	85.83	92.08	70.34	55.62	67.17	270	215	38.80	133.60	15.72	48.54	4.92	141.20	36.90
3	57.18	50.94	85.94	92.14	69.77	55.75	66.82	270	215	39.04	134.30	15.80	49.10	5.34	142.06	37.68
4	61.38	51.23	76.18	86.04	108.98	91.13	82.16	265	216	37.78	128.42	19.78	47.72	5.00	126.84	25.00
5	58.16	52.23	76.40	82.24	64.82	53.29	54.77	267	216	39.42	114.30	16.02	50.40	6.26	133.56	38.56
6	58.01	52.11	76.40	82.25	64.76	52.87	54.91	266	215	39.48	114.60	15.88	50.36	6.06	133.32	38.26
7	60.26	50.41	73.35	82.89	105.20	88.36	75.56	265	215	37.36	121.60	19.70	47.08	4.94	123.20	24.38
8	57.86	52.09	66.83	72.40	62.53	51.61	47.50	270	215	39.22	97.60	16.38	50.44	6.42	125.56	39.40
9	57.73	51.99	66.70	72.21	61.90	51.52	47.45	270	215	39.04	97.10	16.50	50.26	6.40	125.52	39.42
10	60.41	52.75	85.19	92.55	82.53	68.68	75.36	269	215	39.18	137.60	17.52	50.32	6.30	140.08	34.04
11	52.42	46.87	85.43	91.15	64.37	49.67	65.60	270	215	36.52	130.90	15.44	45.50	4.04	143.84	40.62
12	52.76	47.18	85.48	91.26	65.23	49.88	65.65	271	215	36.72	131.30	15.44	45.76	4.18	143.84	40.60
13	57.18	47.70	75.99	85.29	104.32	85.37	80.00	269	216	35.84	125.90	19.12	44.72	3.92	126.00	25.20
14	51.98	45.75	75.92	82.22	70.47	55.69	59.56	268	215	35.60	114.96	16.24	43.98	3.46	129.06	33.64
15	52.68	46.37	76.08	82.44	71.04	56.46	59.75	268	215	35.82	115.62	16.14	44.56	3.80	129.42	33.90
16	56.21	46.30	71.37	81.08	107.86	88.77	78.90	267	215	34.68	119.60	19.76	43.16	3.48	120.78	23.10
17	52.35	46.03	66.95	73.13	69.81	56.84	52.47	271	216	35.08	99.90	17.14	44.26	4.28	120.82	33.32
18	52.19	45.88	66.80	72.96	69.39	56.43	52.38	271	215	34.82	99.50	16.92	43.98	4.14	120.68	33.36
19	55.06	47.33	80.93	88.53	85.67	69.31	74.51	270	215	35.98	129.10	17.32	44.94	4.06	133.02	30.66
20	47.79	41.78	81.21	87.37	69.76	53.58	64.25	272	214	34.04	122.70	15.42	40.92	2.02	133.20	33.90
21	48.76	43.04	81.13	87.01	66.04	51.15	63.40	270	215	34.40	123.50	15.94	41.92	2.62	136.44	36.74
22	54.15	44.44	71.19	80.74	106.18	87.03	78.67	267	215	33.32	118.30	19.50	41.42	3.28	121.02	23.98
23	48.87	42.94	71.23	77.15	66.41	53.00	54.84	270	214	33.76	105.80	16.48	41.46	2.90	124.68	33.86
24	48.86	42.94	71.23	77.16	66.66	52.96	54.87	270	215	33.76	106.00	16.54	41.48	2.90	124.62	33.72
25	51.76	43.00	67.07	75.59	94.99	78.32	66.19	267	214	32.98	107.30	19.36	40.82	3.24	115.68	24.12
26	49.87	43.68	66.58	72.77	69.27	55.38	52.67	269	215	33.66	99.40	17.08	41.94	3.58	119.74	32.54
27	49.79	43.59	66.53	72.76	69.65	55.52	52.66	269	215	33.54	99.10	16.86	41.78	3.44	119.62	32.56

## 2.8 Defective Pilot Valve

The defective pilot valve was the only preexistent fault tested in the chiller. The fault was suspected during the commissioning phase of the chiller test facility, when the superheat could not be properly adjusted. Once the pilot valve was replaced, a substantial improvement in the superheat control as well as overall capacity confirmed the suspicion.

The pilot valve is a simple thermal expansion valve with a sensing bulb in the evaporator. It regulates refrigerant flow in a small liquid line that runs parallel to the main liquid line. This ‘siphoned’ refrigerant is then returned to the main liquid line via the main valve. The main valve position is controlled by the amount of refrigerant entering it via the liquid line controlled by the pilot valve.

Although data was collected before the pilot valve was replaced, there was one drawback—the condenser water flow was not yet up to specifications (its average flow rate was 20% lower than ARI standards, and its flow rate varied by as much as  $\pm 10\%$  during a test run). These problems were eventually solved, yet the fault data still needed to be compared to a normal test case under similar flow conditions. Therefore, the benchmark data set was selected from a test run completed a few days after the pilot valve replacement (it took a few days to properly adjust the superheat settings for all the operating conditions).

Table 2.66: DPV test run steady state data

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	59.17	50.32	85.06	95.77	101.52	79.65	76.35	228	216	37.16	125.80	11.24	47.20	5.04	126.58	25.86
2	55.08	49.24	82.59	89.64	67.15	52.49	55.38	229	216	37.20	109.30	7.74	47.50	5.42	128.72	36.14
3	53.33	50.54	84.58	88.16	34.31	24.99	40.26	230	215	38.64	103.90	5.00	50.12	6.60	152.96	63.68
4	60.07	50.14	75.08	88.25	112.10	89.48	72.97	204	216	35.86	111.60	12.70	46.52	5.60	118.38	24.54
5	55.99	50.69	74.63	80.93	60.53	47.86	46.68	231	216	37.26	93.00	6.88	48.92	6.80	124.04	40.40
6	52.43	50.08	74.75	77.83	29.53	21.05	33.99	230	215	38.58	85.20	3.48	50.00	6.64	149.82	70.96
7	58.50	50.12	69.25	80.09	92.66	75.45	58.24	205	216	36.66	94.90	10.12	47.20	5.58	112.58	27.92
8	55.18	49.86	62.14	69.00	58.77	47.96	39.46	205	216	36.66	74.10	6.90	48.18	6.58	112.12	40.28
9	52.48	49.83	59.86	63.12	31.51	23.78	29.74	232	215	37.62	63.20	2.48	49.60	7.10	131.96	67.90
10	54.40	45.65	85.17	95.74	100.08	78.59	79.27	227	216	35.00	124.40	9.88	43.36	3.40	125.38	25.22
11	50.29	44.86	85.04	91.75	63.78	48.63	57.28	228	215	35.16	112.80	6.76	43.62	3.48	130.34	36.18
12	48.04	45.18	82.88	86.73	36.87	25.72	40.62	230	216	36.20	100.60	4.16	45.06	3.94	145.20	57.46
13	54.74	45.15	73.11	85.31	108.18	86.21	69.58	213	216	34.16	104.30	10.10	42.46	3.44	112.82	22.78
14	50.22	44.74	75.17	81.79	63.30	49.19	49.13	230	216	34.74	94.20	6.42	43.40	3.60	119.78	35.34
15	47.69	45.11	74.84	78.31	33.42	23.22	35.80	231	216	36.22	85.70	3.54	45.02	3.96	140.94	61.74
16	55.42	45.58	69.57	82.49	110.74	88.57	68.81	206	216	34.06	100.40	11.10	42.70	3.70	110.42	22.58
17	49.47	44.02	59.29	66.48	61.79	48.83	39.59	206	215	33.70	70.10	6.64	42.74	4.22	105.50	36.18
18	47.81	45.44	60.46	63.47	29.11	21.17	29.60	232	215	35.72	63.00	2.00	45.48	4.78	131.66	67.40
19	48.28	40.18	80.26	89.92	92.28	72.74	69.60	229	215	32.72	111.10	8.68	38.46	1.02	110.66	17.32
20	45.76	39.88	77.92	85.20	69.62	52.74	54.40	230	215	32.78	100.10	6.82	38.88	1.46	117.12	29.38
21	42.83	39.93	77.23	81.26	38.73	26.01	40.17	231	215	33.58	88.50	0.28	39.56	0.94	128.30	47.14
22	49.37	40.71	68.36	78.88	96.18	77.65	61.49	219	215	32.18	92.90	9.96	39.14	2.20	106.18	22.72
23	44.44	39.19	66.84	73.24	61.38	47.13	43.89	230	215	32.14	79.40	5.76	38.48	1.64	108.80	33.38
24	42.90	40.35	67.29	70.83	34.13	22.84	33.34	231	215	33.54	73.00	2.06	40.46	1.96	127.96	56.78
25	50.43	40.40	65.12	78.06	110.34	90.01	66.60	205	215	31.90	92.50	11.28	37.76	1.16	104.02	20.90
26	46.06	39.92	59.52	67.30	69.56	55.09	42.99	215	215	31.88	71.60	7.08	39.06	2.60	101.18	30.82
27	42.36	39.97	58.91	62.20	31.72	21.43	29.73	231	215	33.00	61.00	1.42	40.26	2.44	123.12	60.54

## 2.9 Multiple Faults

Since the defective pilot valve occurred early in the commissioning phase of the project, it was not possible to isolate it as well as the other faults that were deliberately introduced. Although it was possible to compare the defective pilot valve fault with a benchmark test under the same operating conditions, both sets of tests still suffered from a reduced condenser water flow rate.

This prompted the question of whether multiple faults present simultaneously would produce the same result as if both faults were present separately then added together. Other possible outcomes from adding faults could lead to magnifying or diminishing the effects of the other faults present.

The possible combinations of multiple faults are staggering and are not within the scope of this research project. However, the effect of multiple faults involving the condenser water flow rate is relevant to settle the question as to the reliability of the defective pilot valve test data.

Since the defective pilot valve had an impact on the evaporator, it was decided to create a fault where the condenser and evaporator water flow rates were each reduced by 20%. Recall that the uncertainty of the condenser water flow measurement is  $\pm 2.8$  gpm and for the evaporator water flow it is  $\pm 2.2$  gpm.

**Table 2.67: FWE20FWC20 test run steady state data**

Test	TEI	TEO	TCI	TCO	Cond Tons	Evap Tons	kW	FWC	FWE	PRE	PRC	TRC_sub	T_suc	Tsh_suc	TR_dis	Tsh_dis
1	61.25	50.41	85.58	96.61	96.69	79.85	78.76	210	177	36.94	127.84	10.82	46.80	5.00	127.64	25.80
2	57.06	50.67	85.24	91.80	57.92	47.11	54.60	212	177	37.74	113.60	7.28	48.74	5.94	134.40	39.72
3	53.34	50.09	85.04	88.63	31.71	24.00	39.64	212	177	38.64	104.60	5.00	49.72	6.32	154.52	64.20
4	61.27	49.71	75.47	86.71	100.88	85.16	69.24	215	177	35.88	108.30	10.24	45.86	5.02	116.06	24.04
5	57.09	50.61	75.32	81.63	57.52	47.86	47.18	219	177	37.58	94.80	6.86	48.70	6.18	123.76	38.84
6	52.75	49.94	75.28	78.38	27.96	20.70	34.12	217	177	38.82	86.60	3.90	49.80	6.18	150.04	69.82
7	59.02	49.38	70.34	79.90	83.76	71.37	56.12	210	178	35.94	94.60	8.88	46.32	5.50	112.46	27.94
8	56.31	49.99	65.54	71.84	55.41	46.77	40.96	211	178	36.70	79.00	6.70	48.00	6.46	114.82	39.84
9	53.43	49.85	63.15	66.73	32.28	26.50	31.85	216	177	37.86	69.30	3.74	49.30	6.58	130.46	61.86
10	55.23	45.24	85.31	95.49	91.05	73.79	76.99	215	177	34.42	120.70	7.72	42.70	3.34	126.30	27.94
11	51.45	45.22	85.33	91.81	58.13	45.91	56.02	215	177	34.84	113.40	6.90	43.72	3.88	132.60	37.98
12	48.55	45.08	85.02	88.93	35.17	25.63	42.21	216	177	35.76	105.60	5.36	44.72	3.92	147.68	57.10
13	56.66	45.39	75.11	86.35	100.06	82.94	70.88	214	177	33.16	107.50	10.24	41.96	4.12	114.94	23.28
14	50.99	44.62	75.28	81.69	57.74	46.97	48.38	216	177	34.18	95.00	6.74	42.94	3.80	121.38	36.54
15	48.13	45.25	74.95	78.18	29.27	21.23	34.84	217	177	35.60	86.20	3.72	45.10	4.42	145.42	65.74
16	56.36	44.99	70.32	81.45	100.18	83.99	65.95	216	177	33.28	98.90	9.90	41.74	3.60	109.88	22.90
17	51.50	44.43	64.80	71.63	61.90	52.19	44.09	218	177	32.96	79.30	7.32	42.40	4.66	109.28	34.08
18	48.42	45.12	64.89	68.39	31.87	24.42	32.23	218	177	35.36	71.40	3.70	44.74	4.44	130.32	60.30
19	50.26	40.60	79.03	88.63	86.69	71.22	67.26	217	177	32.02	110.20	9.36	38.58	2.08	116.86	23.92
20	46.87	40.79	79.94	86.29	57.51	44.91	52.56	217	177	32.26	103.14	6.96	39.74	2.78	125.28	36.04
21	43.87	40.42	79.88	83.87	36.11	25.37	40.51	217	177	32.96	96.80	4.76	40.20	2.66	139.46	53.84
22	52.21	40.45	69.88	81.32	102.50	86.63	69.49	215	177	30.56	98.80	10.72	37.60	2.52	108.20	21.36
23	45.67	39.27	68.90	75.41	59.15	47.13	46.02	218	177	30.86	84.60	7.20	38.08	2.76	112.36	33.58
24	43.49	40.23	69.24	72.93	33.42	24.13	34.93	218	177	32.50	78.60	4.18	39.94	2.72	130.30	55.62
25	49.21	39.81	63.18	72.23	81.80	69.38	52.66	217	177	30.38	81.70	9.16	37.72	2.76	102.48	30.70
26	46.16	40.17	61.27	67.19	53.29	44.18	39.43	216	177	30.68	72.00	6.34	38.78	3.54	106.98	36.40
27	43.08	39.87	61.58	65.08	31.70	23.72	31.41	218	177	32.28	66.30	3.14	39.80	2.90	123.28	56.92

### **3.0 Conclusion and Recommendations**

This report contains no information regarding how well the given data actually reached steady state. Generally the vast majority of variables have a rate of change less than 0.2% per minute (analysis contained in the workbook titled 'steady state analysis'). The worst cases (ignoring those explicitly mentioned in Table 2.3) have a rate of change of about 1.25% per minute. It is recommended that each researcher determine what is an acceptable rate of change to meet steady state criteria (the data here is not intended to be used as training data, just as a reference).

Back in Table 2.4 a list of suitable benchmark data is provided. Usually those normal tests performed the closest to the fault tests as indicated in Table 2.3 are the best choice (the exceptions being when the test does not meet the steady state or operating conditions criteria set forth by the researcher).

The data contains both measured variables and calculated variables. The base variables should be used in all circumstances, since the on-line calculation method used in the data collection process is simplistic. Refer to Table 2.2 to see which variables were calculated by VisSim (the control software used during the experimental testing).

The CD-ROM also contains data from the commissioning phase of the chiller. The spreadsheets within these workbooks do not follow the rigid structuring used during the fault testing. Finally, the workbooks used for preliminary comparison of the fault data are also available on the CD-ROM.